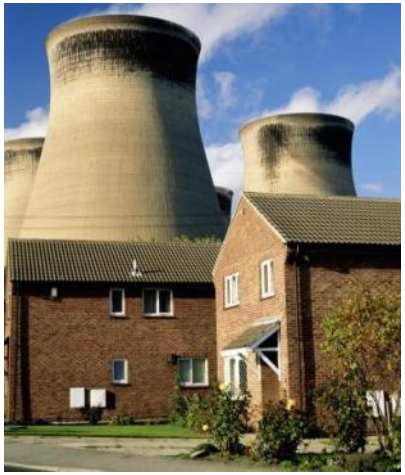


Tim McAloone

Technical University of Denmark
Department of Management Engineering
Section of Engineering Design & Product Development

Eco-Innovation in the Value Chain

25-10-2011

Engineering for the 21st Century
University of São Paulo

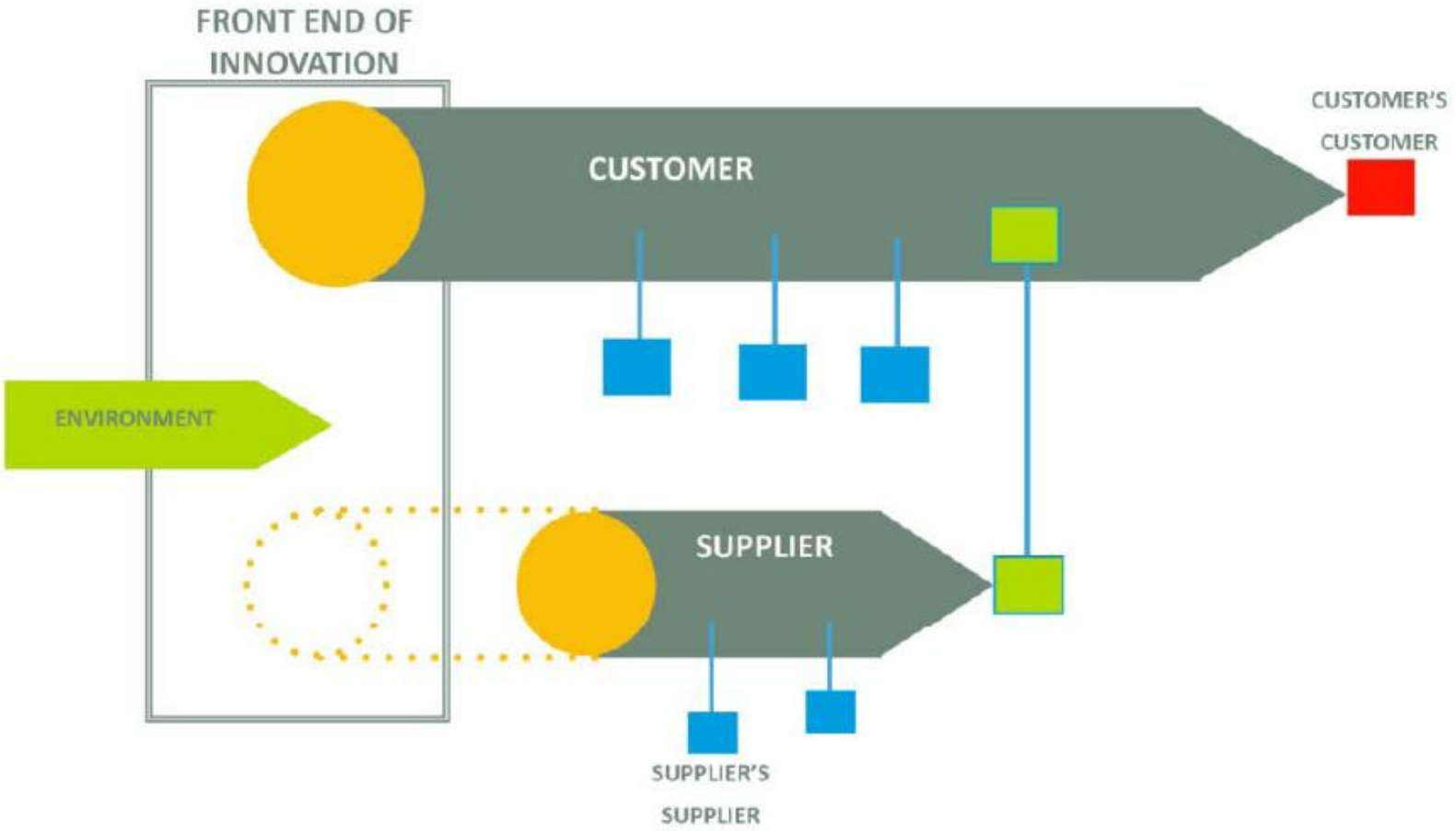
Disposition

Implementing sustainable design strategies

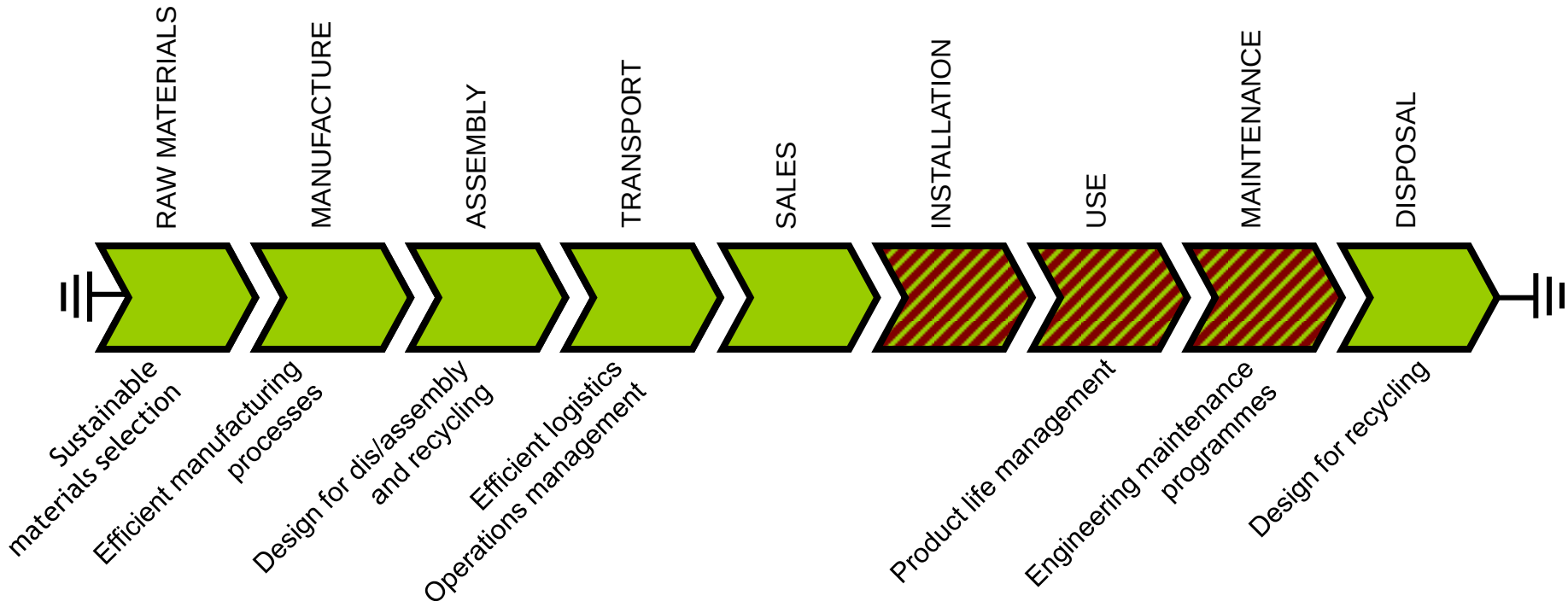
- Some definitions
- Motivation for this work
- Four proposed focus areas:
  - Life cycle thinking
  - Environmental stewardship
  - Sustainability in the value chain
  - Sustainability as a driver for innovation
- Teaching eco-innovation / sustainable product development
- Reflections and conclusions

DTU

Eco-Innovation in the value chain:
An engineering task



Eco-Innovation in the value chain:
An engineering task



What’s in a name?
A few definitions

['Inkuku’, Ryan Frank]

[www.instructables.com]

[Thomas Owen, University of Derby]

What's in a name?
A few definitions

['A-Pump' from Grundfos]

[Mechatronic Cycle Lamps from Reelight]

[Please chair from Steelcase]

GLOBAL WARMING is soooo 2009

Now they're all talkin' 'bout

CLIMATE CHANGE
RESOURCE DEPLETION
CLIMATE INDUCED PANDEMICS
OVER POPULATION
INEQUITY
CLIMATE REFUGEES

Resource depletion examples / Factor X

- In 2050 we will need 8.5 planets to absorb the amount of **$C0_2$** produced

- In 2050 it will take 3.5 planets to sustain the amount of **cement** currently used

- In 2050 3.5 planets will be needed in order to meet our current levels of **wood** consumption

- In 2050 3.5 planets will be required to meet our current **steel** consumption levels

[demi project, UK]

CO_2 per capita per country

Per-capita rank from Wikipedia

Rank	Country	Tonnes per capita per annum 1991	2000	2007
1.	Qatar	36.7	56.3	55.4
12.	United States	18.9	20.0	18.1
27.	Finland	11.0	10.1	12.1
37.	Germany	12.0	10.1	9.6
43.	United Kingdom	10.3	9.2	8.9
45.	Denmark	11.9	8.8	9.2
65.	France	7.5	6.2	6.1
72.	Switzerland	6.2	5.4	5.1
74.	Sweden	6.4	5.7	5.4
78.	China	2.2	2.7	4.9
124.	Brazil	1.4	1.9	1.9
145.	India	0.8	1.1	1.4
210.	Afghanistan	0.2	0	0
214.	Mali	0	0.1	0

[Based on UN data published on Wikipedia]

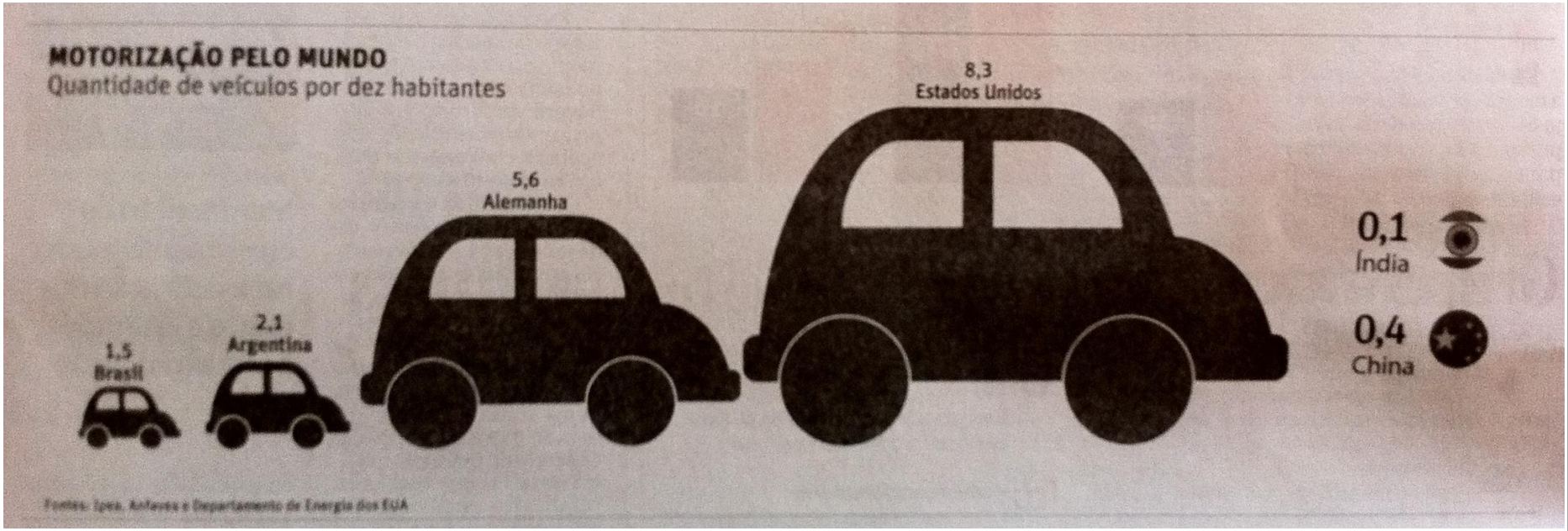
Total CO_2 production per country (2007 figures)

Per-capita rank from Wikipedia

Rank	Country	CO2 per annum (mio. tonnes)
78.	China	6,564.53
12.	United States	5,647.20
145.	India	1,694.28
37.	Germany	785.28
43.	United Kingdom	554.47
65.	France	401.38
124.	Brazil	365.56
1.	Qatar	94.18
27.	Finland	65.34
45.	Denmark	51.52
74.	Sweden	50.76
72.	Switzerland	40.29
210.	Afghanistan	0
214.	Mali	0

[Based on UN data published on Wikipedia]

Danger signs...



[Folha, 23/10-2011]

GLOBAL WARMING is soooo 2009

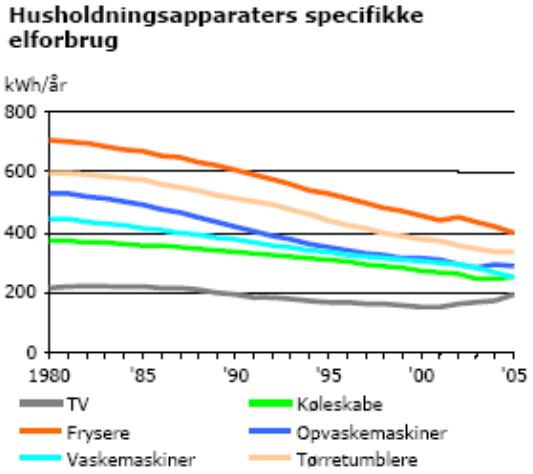
Now they're all talkin' 'bout

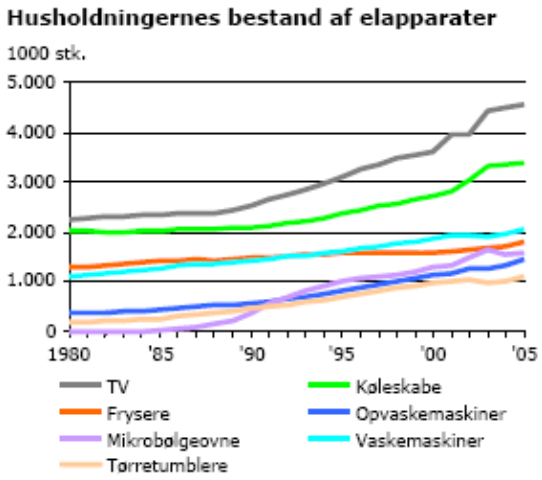
CLIMATE CHANGE
RESOURCE DEPLETION
CLIMATE INDUCED PANDEMICS
OVER POPULATION
INEQUITY
CLIMATE REFUGEES

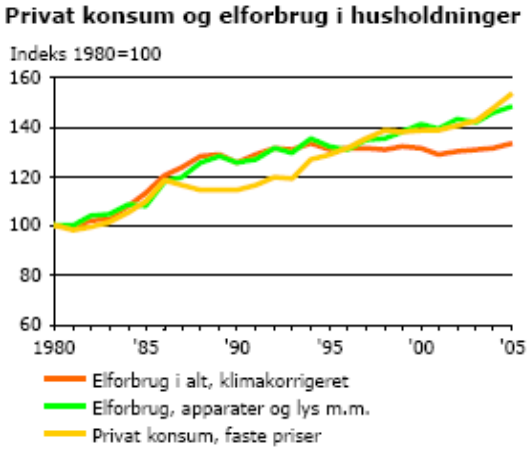
or

SMART TECHNOLOGIES
ENGINEERING EFFICIENCY
CLIMATE TECHNOLOGIES
SUSTAINABILITY-DRIVEN INNOVATION

“Technology just keeps getting better on its own” [W. Young, IBM, 1996]







”… and it surely needs to!”

[Energistatistik 2005, Energistyrelsen, 2006]

"IPAT"

Graedel and Allenby see ***environmental impact*** as a result of three factors:

Population	[P] opulation
Gross Domestic Product (GDP) per person potentially corresponding with quality of life	[A] ffluence
Environmental impact per unit of per capita GDP as the part influenced by technology	[T] echnology

"Master equation":

$$Environmental\ impact = population \times \frac{GDP}{person} \times \frac{environmental\ impact}{unit\ of\ \ per\ capita\ GDP}$$

or:

$$\sum \mathrm{I} = \mathrm{P} \times \mathrm{A} \times \mathrm{T}$$

Challenges on the path to sustainability

- A product's use is not *(traditionally)* defined by the designer, but does the designer have a responsibility for how products are used?

Challenges on the path to sustainability

- Consumers do not feel the consequences of their own personal consumption.

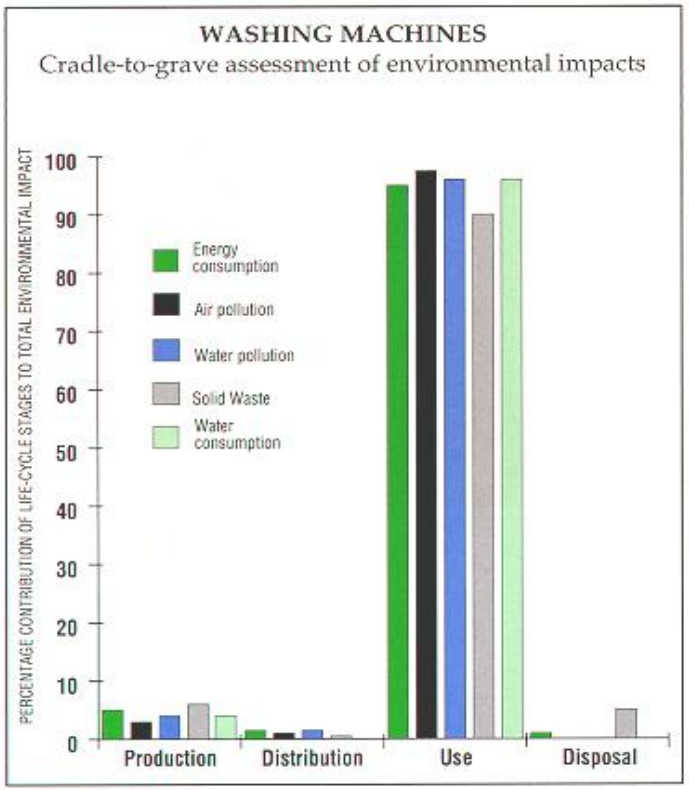
[Basodino Glacier, Canton Ticino, Switzerland 1952 and 2005]

Challenges on the path to sustainability

- Environmental and social responsibility is a collective issue, but consumption is individual.

Two problems of material product ownership (1)

- Product usage
  - The emerging pattern of environmental load vs. responsibility

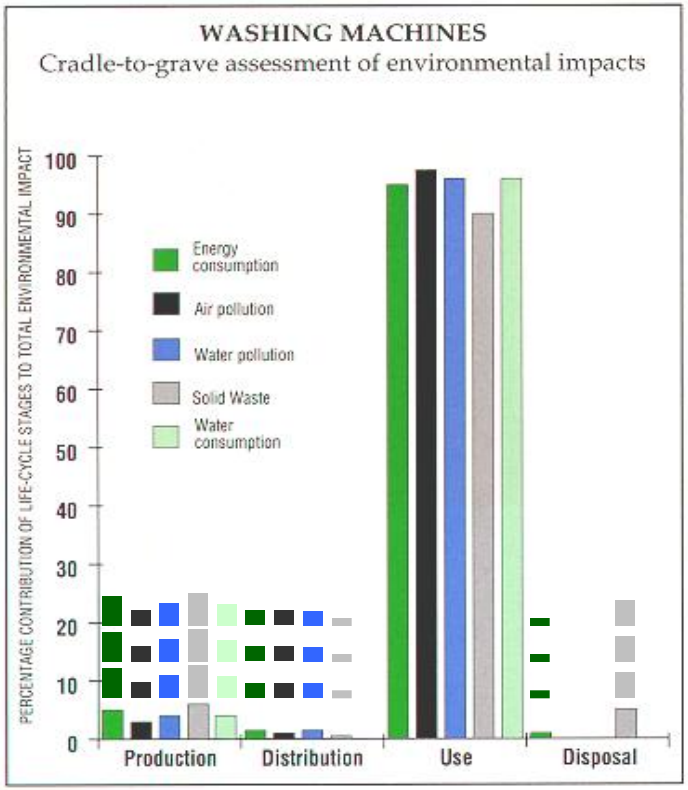


Traditional producer responsibility → **+ WEEE** →

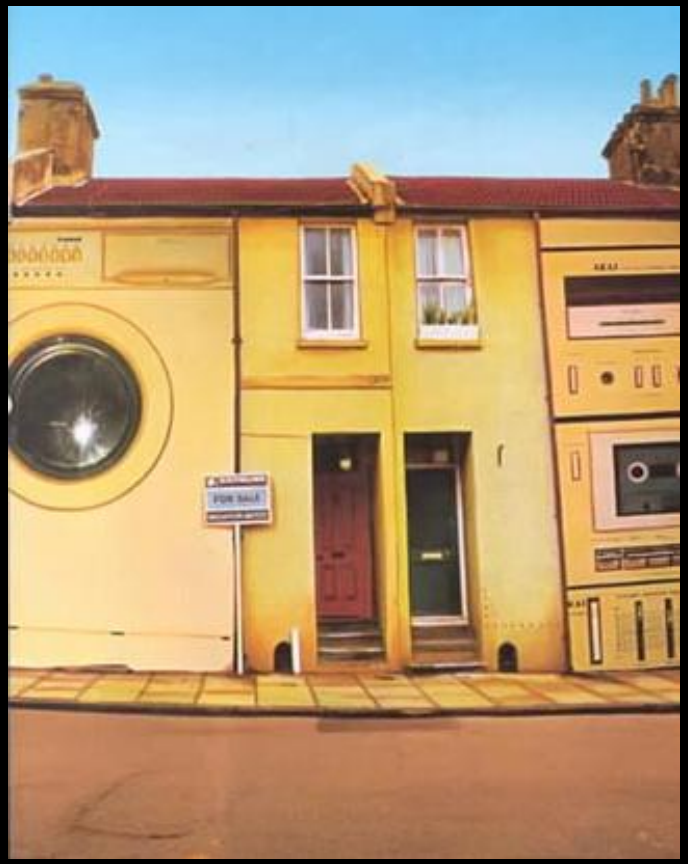
Here's where the action is! →

Two problems of material product ownership (2)

- Consumerism



Consumerism is also designed

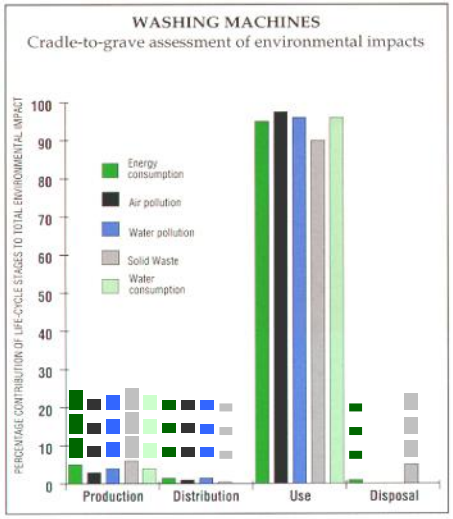


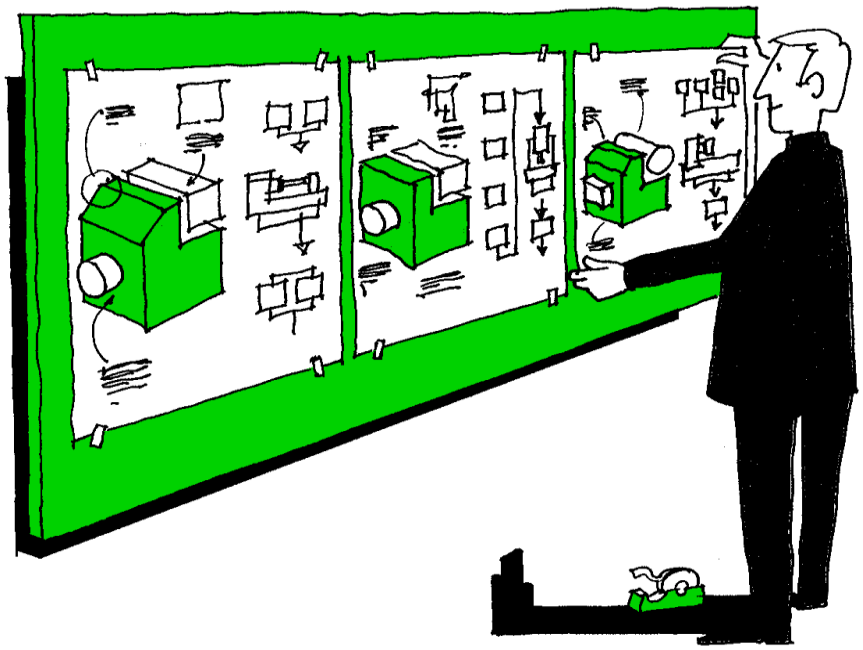
[Whiteley, 1993]

How to break this spiral through design?

Four proposed focus areas:

1. Think, design and communicate in terms of ***lifecycle***, not just product
2. Ingrain ***environmental stewardship*** into the whole business
3. Mandate sustainability in the ***value chain***
4. Viewing sustainability (and not just technology) as a ***driver for innovation***





Focus area 1:

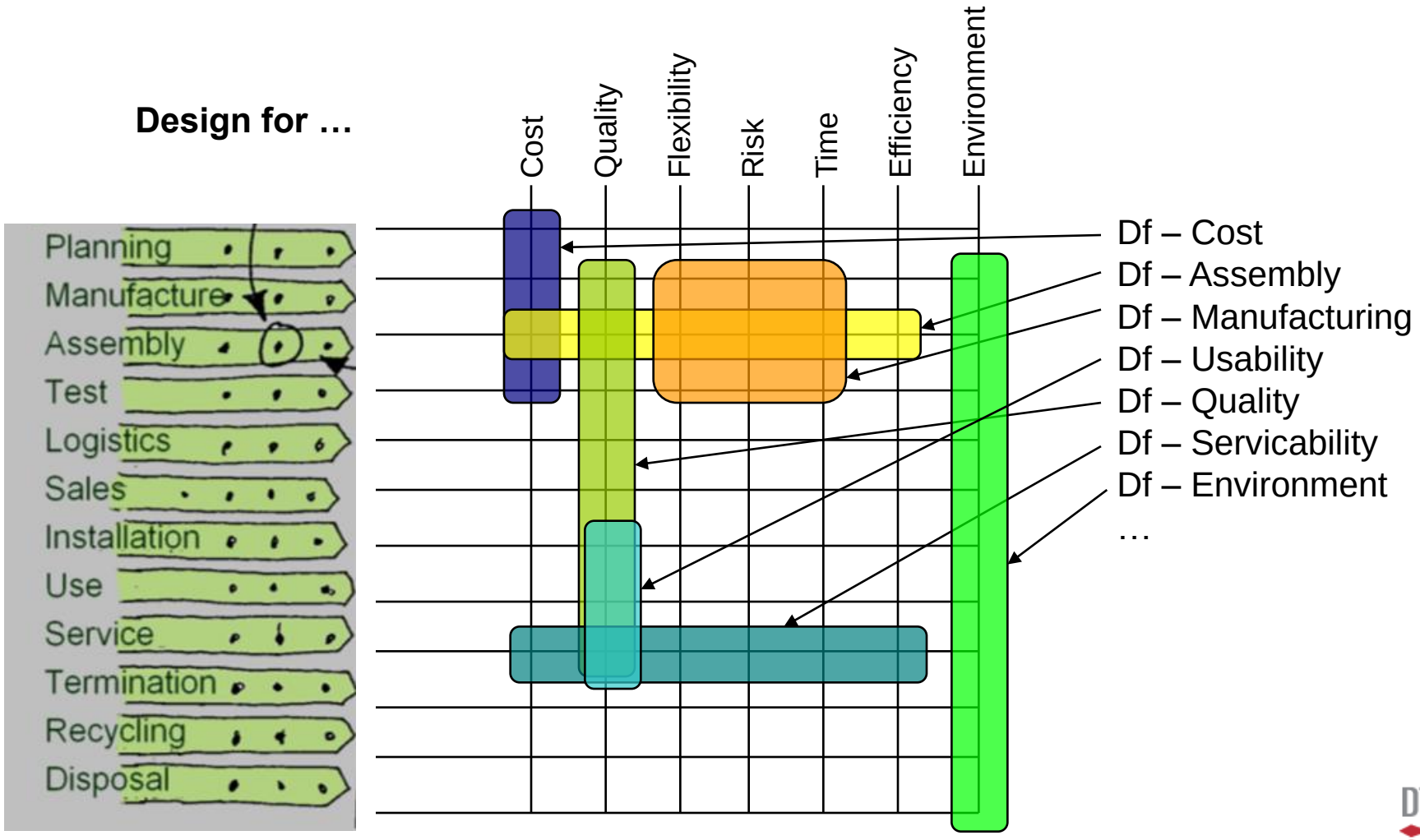
How to think, design and communicate in terms of lifecycle

The size and nature of ecodesign

What's so special about ecodesign (or Design for Environment)?

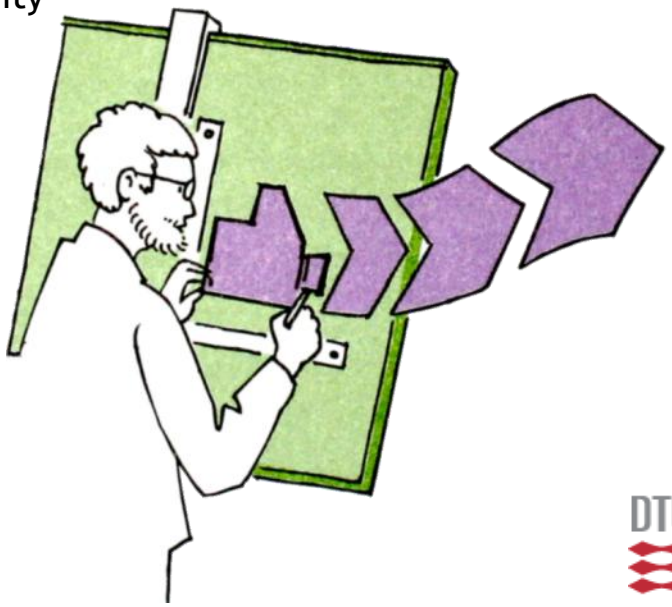
Isn't it just another DfX ..?

The size and nature of ecodesign

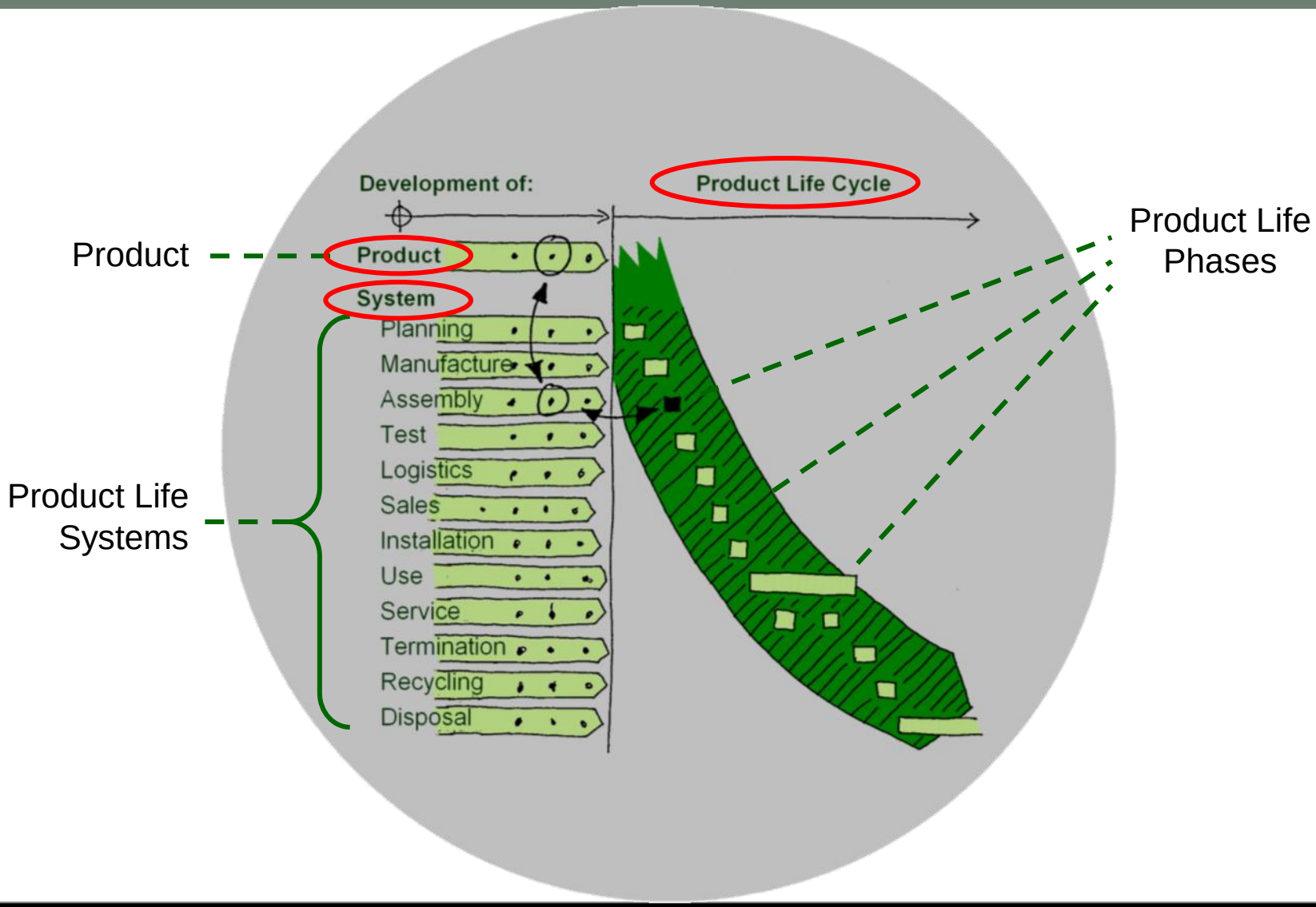


The size and nature of ecodesign
Ecodesign is a complex DfX task

- Acidification
- Biodiversity
- Carcinogenics
- Climate change
- CO_2
- Consumerism
- Corporate social responsibility
- Disassembly
- Drought
- Ecobalancing
- Electronic waste
- Energy consumption
- Equity
- Eutrophication
- Fast turnover of goods
- Flash-floods
- Food crisis
- Global warming
- Greenhouse effect
- Hazardous substances
- Incineration
- Inefficiency
- Lead-free everything
- Materials selection
- Ozone layer depletion
- Packaging
- Peak oil
- Photosmog
- Population growth
- Producer responsibility
- Recyclability
- Resource depletion
- Reuse
- Smog
- Sufficiency
- Toxic emissions
- Transportation effects
- Water shortage
- Weight



What is product life thinking?



Reasons for being product life oriented

- *"For sustainable product development, it is essential, to **first design total product life cycle** in order to make reuse/recycling activities, more visible and controllable, **and then to design products appropriate**, to be embedded in the life cycle."*

[Kimera & Suzuki '96]
CIRP ECO-performance '96 seminar

Life cycle design of a typical industrial kitchen

Materials | Production | Distribution | Use | Disposal

Prep. | Filling | Heating | Cleaning | Storage

Product life cycle (with product life phases)

Product life systems

Product

Actor

Environmental effects only occur in a **"meeting"** between the product, an actor and a product life phase system

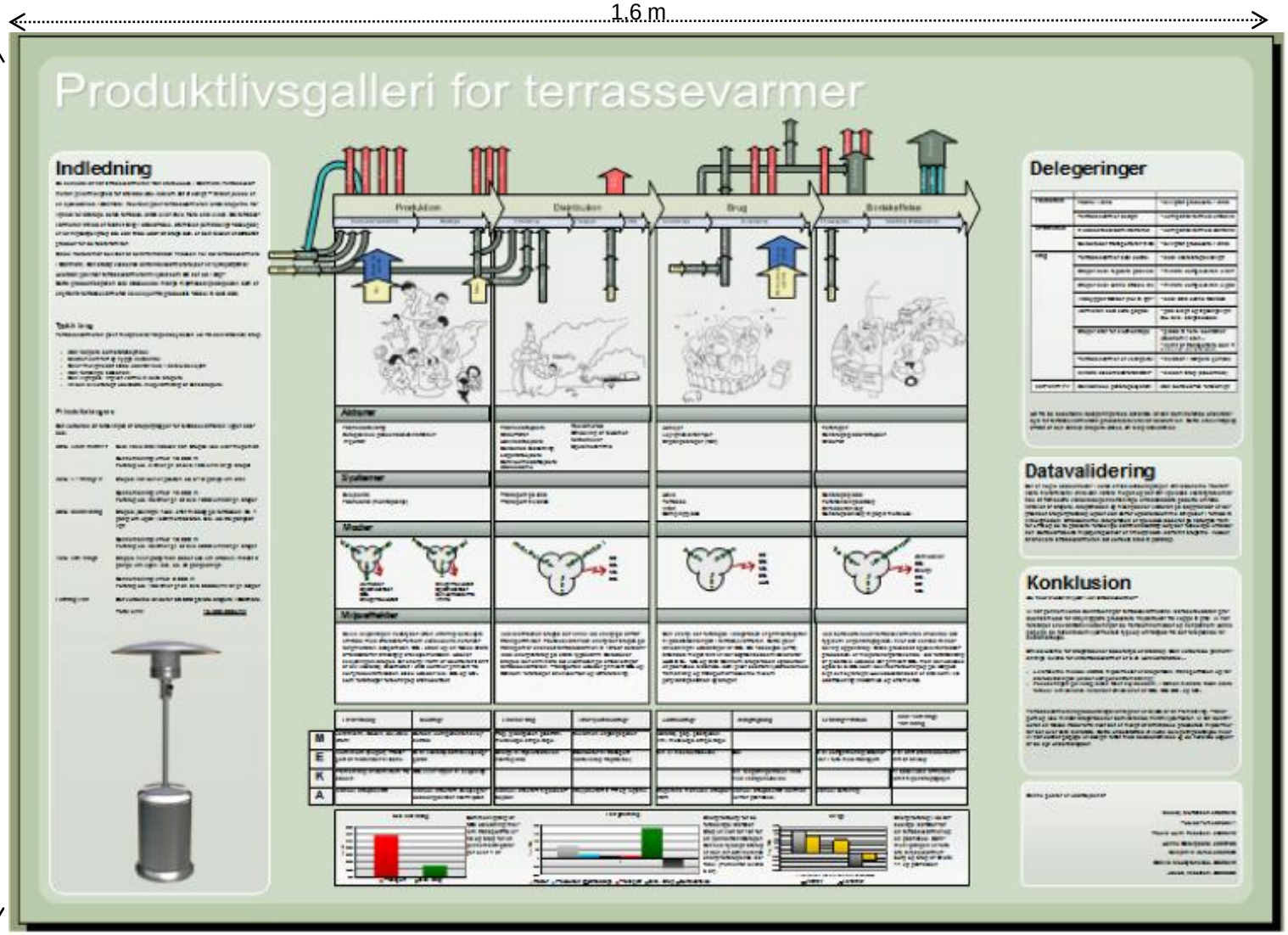
[Olesen, 1992]

One possible solution

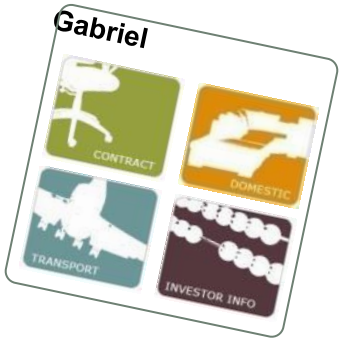
DTU

Two main types of Product Life Gallery

Summative




Life cycle workshop,
Steelcase USA, Sept. ’09



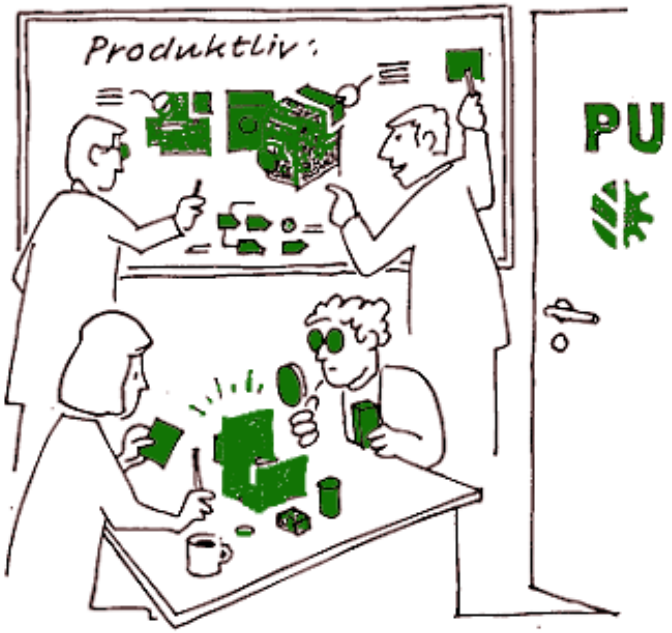
Focus area 2:

Ingraining environmental stewardship into the business

We’re not short of tools…

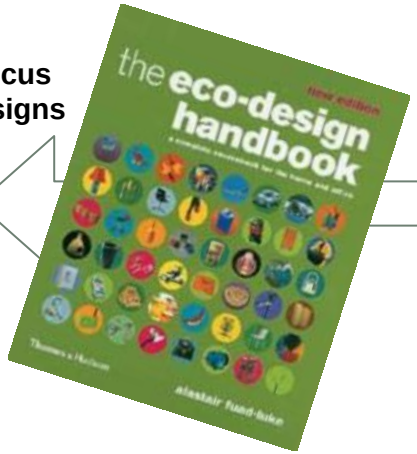
- AT&T Product Improvement Matrix
- BEES (Version 4.0)
- CMLCA (Version 4.2)
- Concept Demonstrators
- DfE: Canadian Standards Association
- ECO It (Version 1.3)
- ECOCLASS (Version 0.3)
- Eco-Compass
- Ecodesign PILOT
- Ecodesign Strategy Wheel
- Eco-Indicator´95
- Eco-Indicator´99
- EcoLab (Version 5.3.2a)
- ECOSCAN (Version 3.0)
- EDGE (Version 3.1)
- EDT (EcoDesign Tool)
- Environmental Champions
- Environmental Performance Indicators
- GaBI (Version 4)
- GaBI DfX
- GaBi Lite
- GEMIS (Version 4.42)
- IDEMAT
- IVF Handbook
- KCL-ECO (Version 4.0)
- LCA Results Workshop
- LCALight
- LCAPIX (Version 2.0)
- Life Cycle Design Manual
- Materials Checklist
- MET Matrices method
- Metrics and Targets
- MIET (Version 3.0)
- Pilot Projects
- Pressures and Drivers Workshop
- Prioritising Workshop
- PROMISE Manual
- REGIS (Version 2.2)
- SIMAPRO (Version 7.1)
- SoFI
- SPINE@CPM
- TEAM™ (Version 4.0)
- TEAM™ IE
- The Boustead Model (Version 5.0)
- TRACI
- Training pilot
- UMBERTO (Version 5.5)
- US LCI DATABASE (Version 1.4.0)
- WISARD (Version 4.0)

- ... and many more



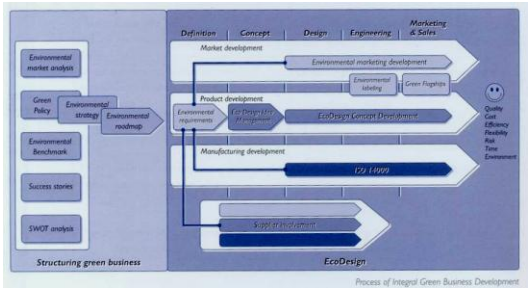
Observation of industrial ecodesign achievements

Single focus
Eco-redesigns

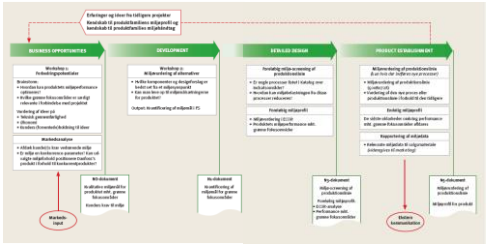


Full scale eco-implementation in ”first-mover” corporations

Philips



Danfoss



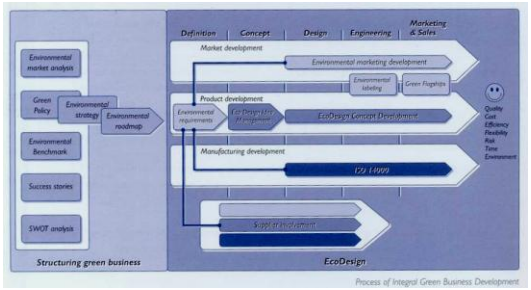
Observation of industrial ecodesign achievements

Single focus
Eco-redesigns

The chasm of non-eco.
Most companies fit into this category

Full scale eco-implementation in first-mover corporations

Philips



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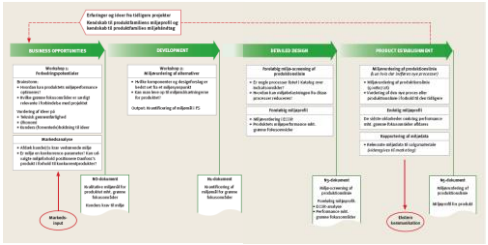
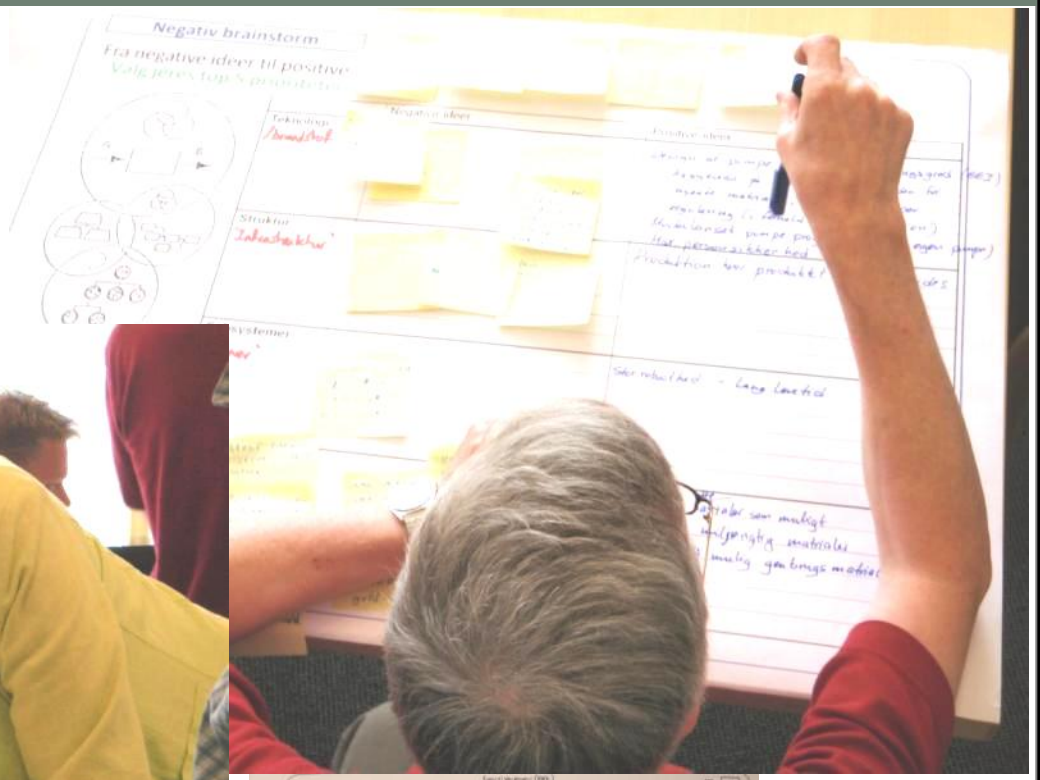
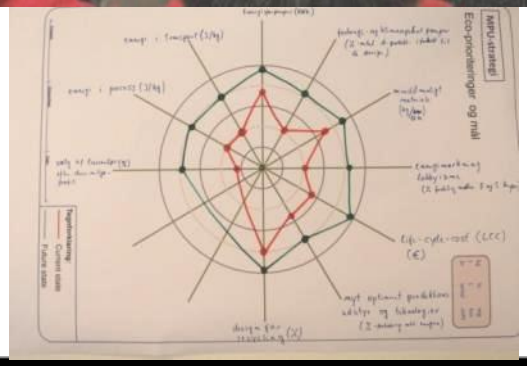


Danish Campaign – Environmental Improvements through Product Development

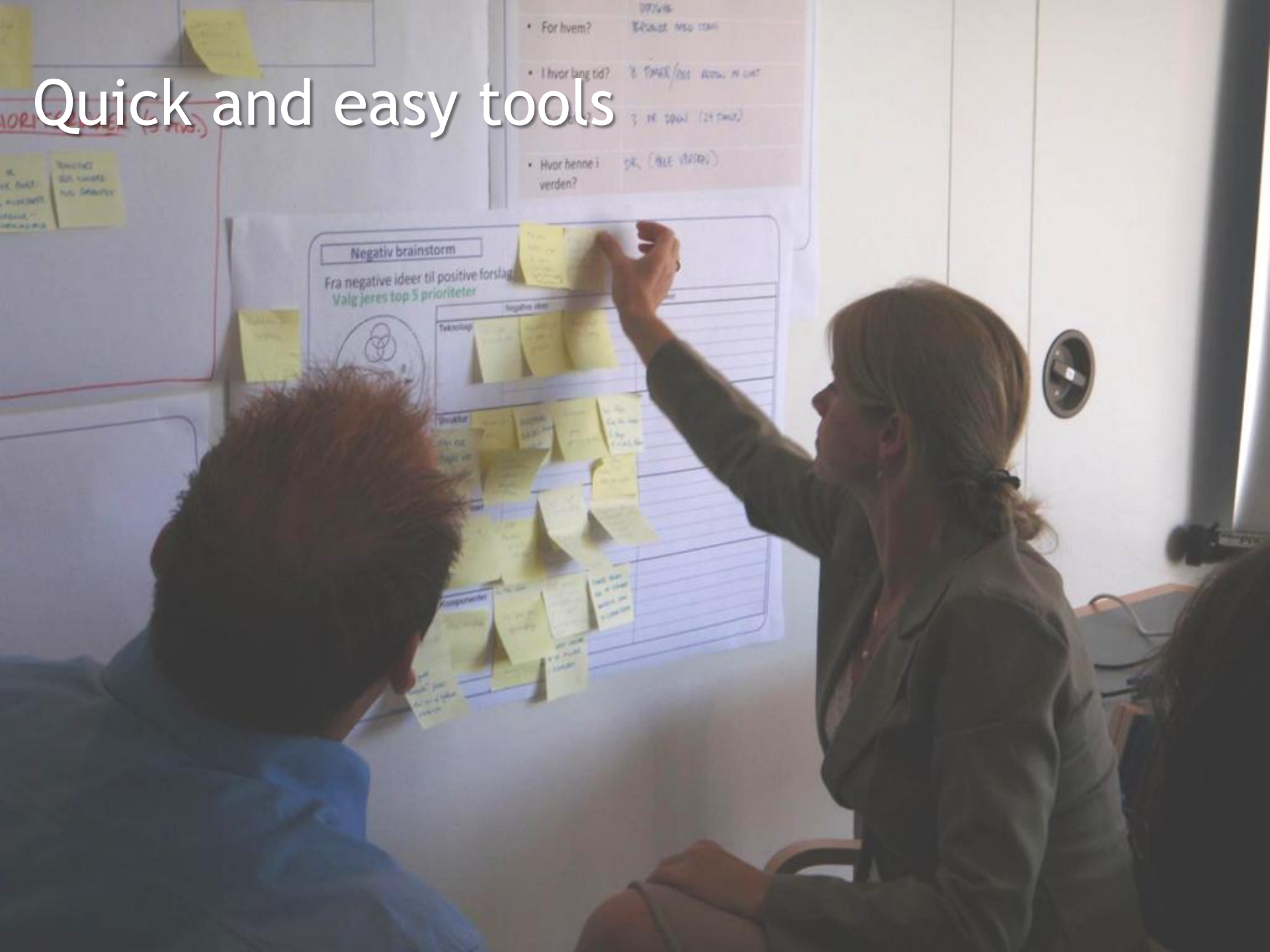




Project background

- **Customer:** Danish EPA
- **Project partners:** DTU & IPU, in collaboration with the Confederation of Danish Industry (DI)
- **Case-companies:** Coloplast, Fritz Hansen, Gabriel, Grundfos, Lego
- **Aim:** To ***strengthen the stewardship and implementation of methods*** for sustainable design in Danish industry
- **Result:** A short handbook describing a framework for sustainable product development

Quick and easy tools



Focus on dialogue

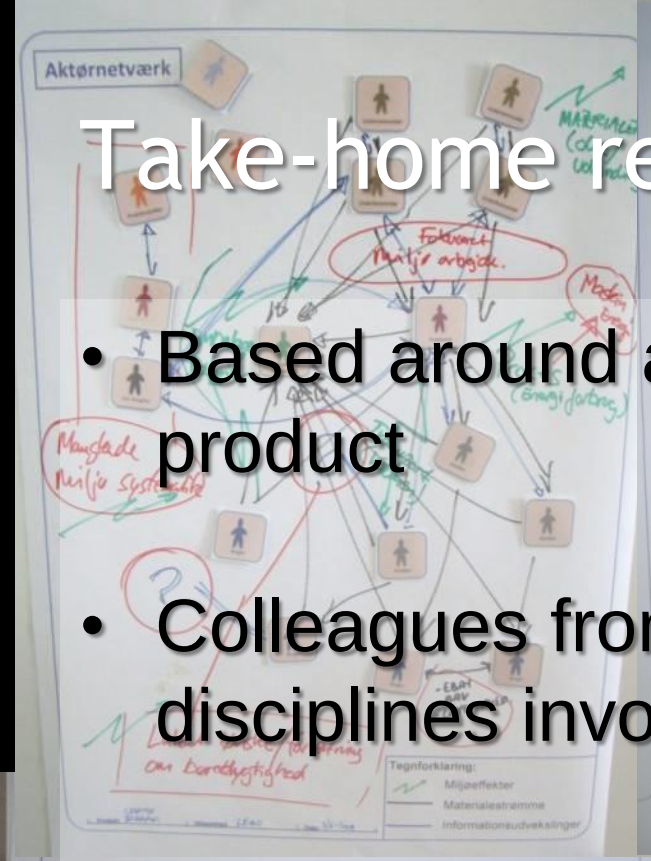
Whole-life thinking

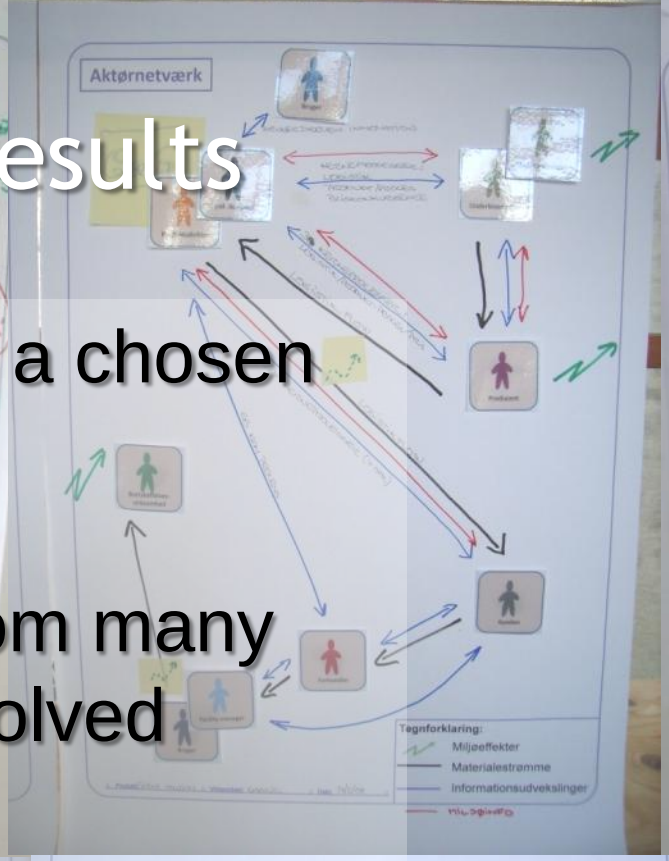
Value-chain considerations

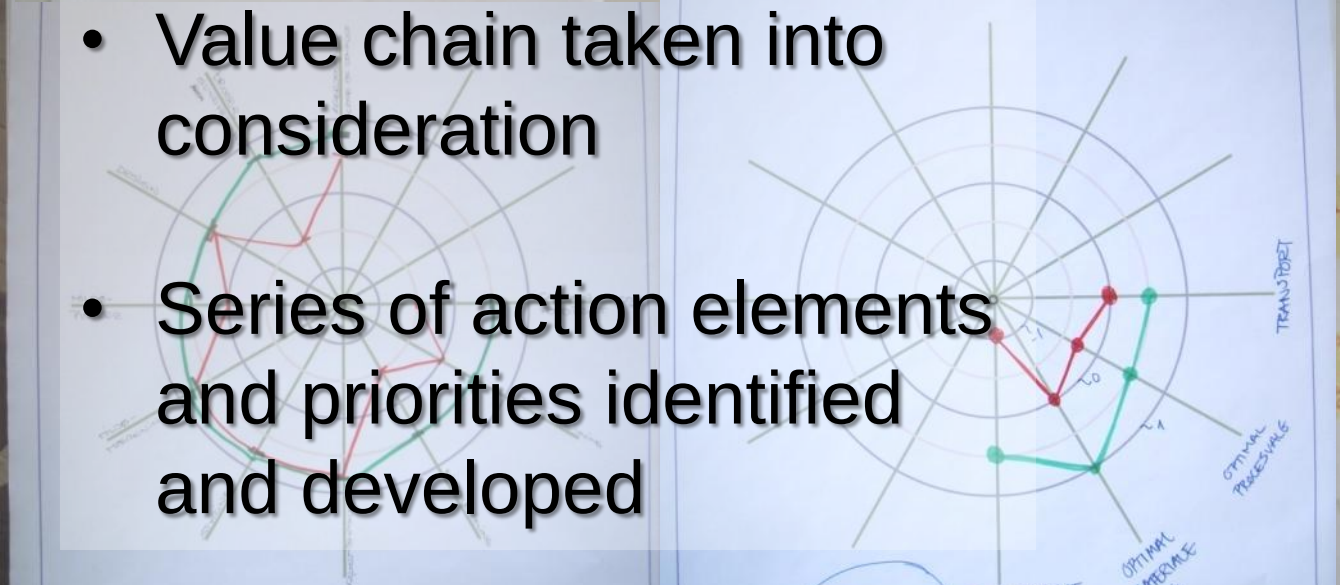
Hands-on exercises

Take-home results

- Based around a chosen product
- Colleagues from many disciplines involved
- Value chain taken into consideration
- Series of action elements and priorities identified and developed







A methodology emerges

Step 1
Use context
How is the product used? By whom? For how long? The central issue here is to uncover the environmental effects that relate to the product's functionality for the user

Step 2
Overview
We expand our view to the lifecycle. How is the product manufactured, distributed, and disposed of? Which environmental effects does this lead to?

Step 3
Eco-profile
The environmental effects shall be split into four categories so they can be compared. What are the reasons for the environmental effects?

Step 4
Actor-network
Draw a network of all actors who come into contact with the product. Plot the connections between these, and identify environmental effects.

Step 5
Quantifying
Put figures on the product's environmental effects. Create scenarios for alternative processes, materials and life cycles. Consider the likelihood of the scenarios

Step 6
Conceptualisation
Try to remove or reduce the environmental effects by creating solutions towards product- or life cycle changes. Use the environmental principles provided and sketch eco-concepts

Steps 1-6 are an innovative, environmental-oriented experiment. Extract your experiences from these steps and make a generalised plan for your company's environmental strategy:

Step 7
Eco-strategy
Make an action plan for the environmental efforts for your company, especially for product development

Main output – A guide for product development

- Guides printed/distributed: 6.000 (4.500 DK + 1.500 UK)
- Available electronically
  Link on www.kp.man.dtu.dk
- Free of charge
- No copyright

Collaboration between departments

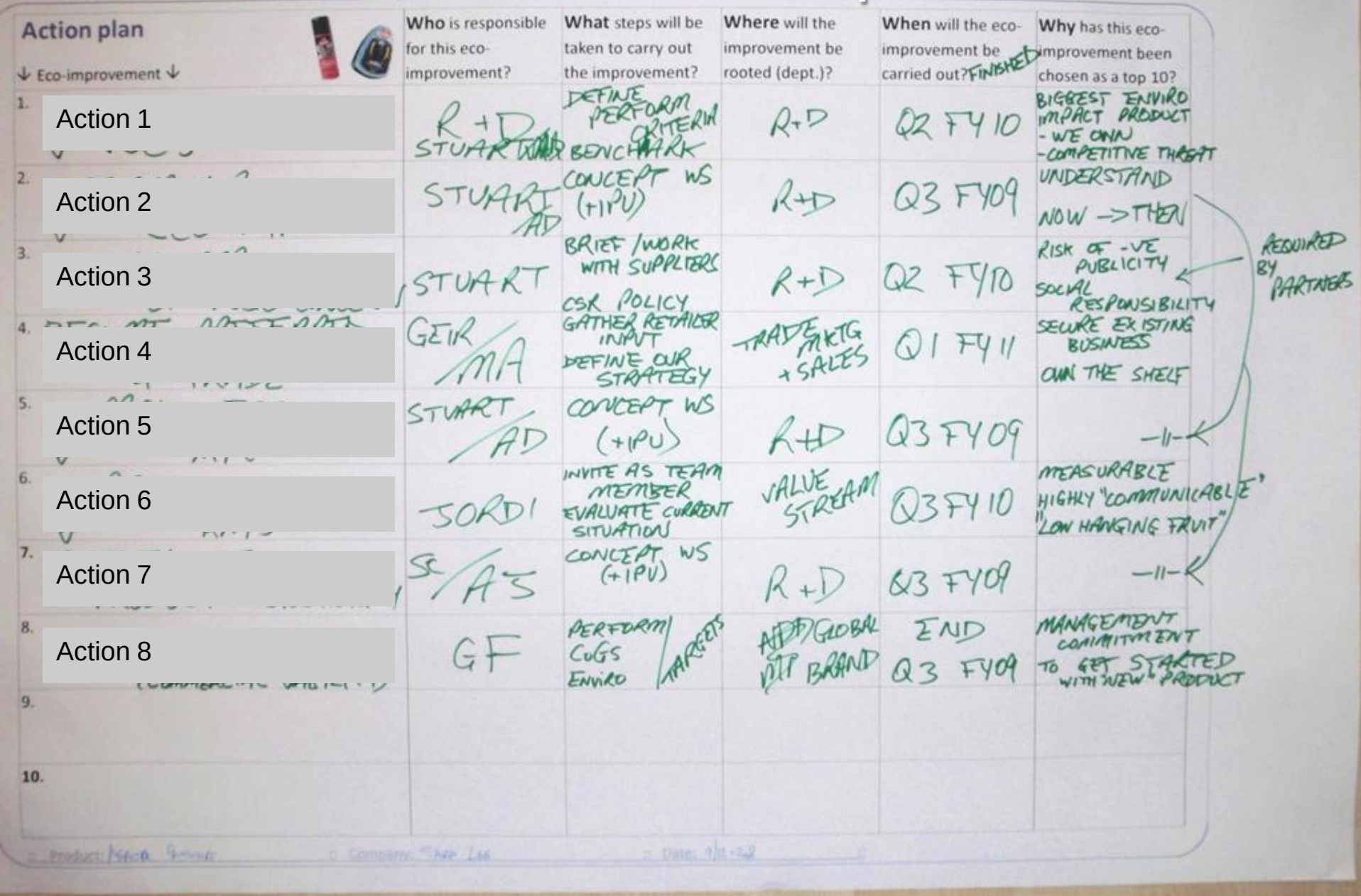
Defining how to change strategy


Exercise: Sustainability Adoption Survey
Your company has.....
Company: Steelcase
Interviewer:
Integrated environmental Management System
Universally shared/understood definition of Corporate Social Responsibility
Universally shared/understood definitions of sustainability
Sustainability Seen & Communicated as a Strategic Platform
Integrated Sustainability Performance Metrics & Rewards for Employees
Formally integrated Sustainability Methods in Product development Process
SAYING
DOING
Knowledge sharing

Visualization

Commitment and follow-up

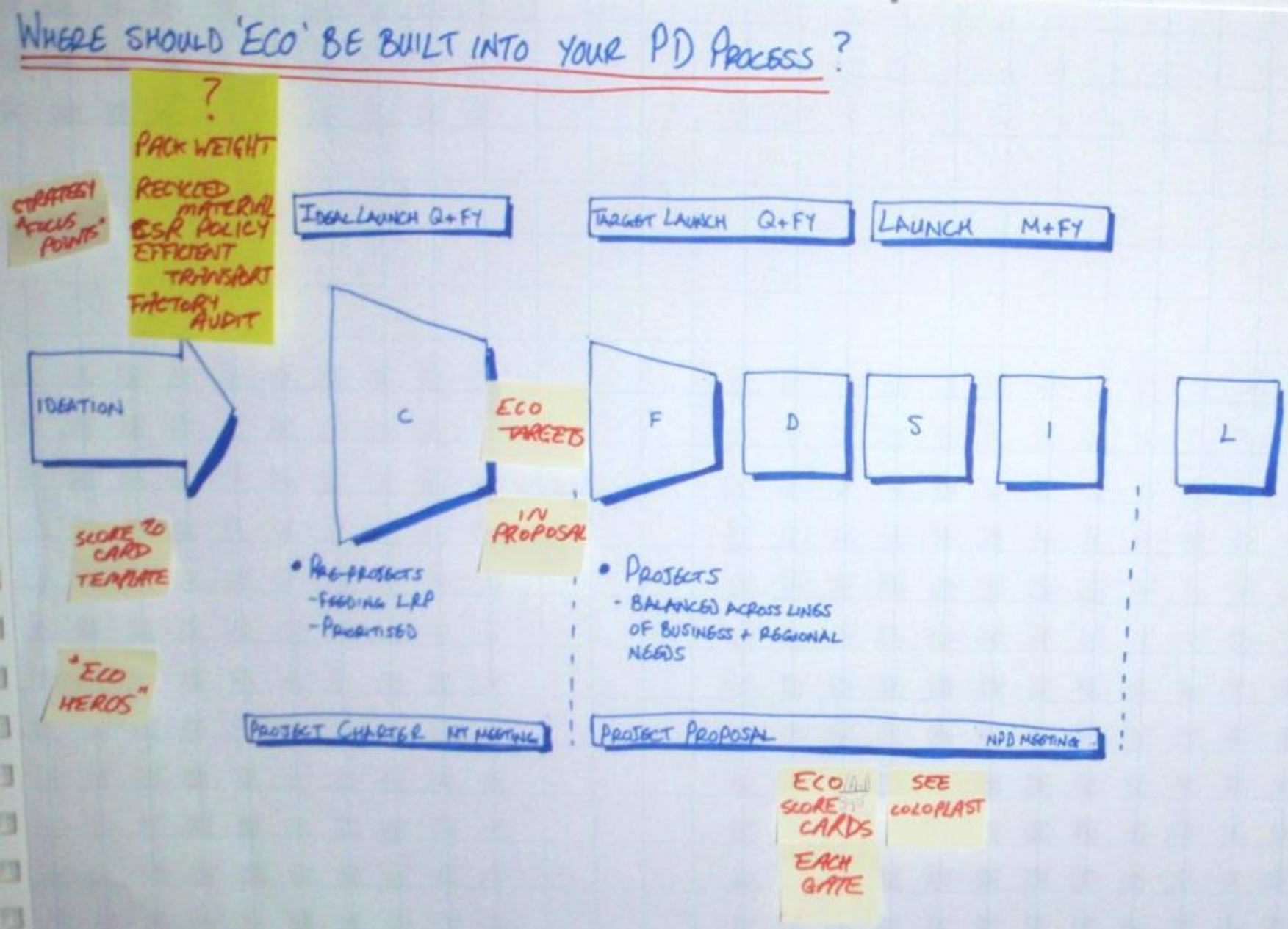
Commitment and follow-up



Action plan ↓ Eco-improvement ↓	Who is responsible for this eco-improvement?	What steps will be taken to carry out the improvement?	Where will the improvement be rooted (dept.)?	When will the eco-improvement be carried out? FINISHED	Why has this eco-improvement been chosen as a top 10?
1. Action 1	R+D STUART	DEFINE PERFORM CRITERIA BENCHMARK	R+D	Q2 FY10	BIGGEST ENVIRO IMPACT PRODUCT - WE OWN - COMPETITIVE THREAT
2. Action 2	STUART AD	CONCEPT WS (+IPU)	R+D	Q3 FY09	UNDERSTAND NOW → THEN
3. Action 3	STUART	BRIEF / WORK WITH SUPPLIERS CSR POLICY	R+D	Q2 FY10	RISK OF -VE PUBLICITY SOCIAL RESPONSIBILITY
4. Action 4	GEIR MA	GATHER RETAILER INPUT DEFINE OUR STRATEGY	TRADE MKTG + SALES	Q1 FY11	SECURE EXISTING BUSINESS OWN THE SHELF
5. Action 5	STUART AD	CONCEPT WS (+IPU)	R+D	Q3 FY09	-11-
6. Action 6	JORDI	INVITE AS TEAM MEMBER EVALUATE CURRENT SITUATION	VALUE STREAM	Q3 FY10	MEASURABLE HIGHLY "COMMUNICABLE" "LOW HANGING FRUIT"
7. Action 7	SC AS	CONCEPT WS (+IPU)	R+D	Q3 FY09	-11-
8. Action 8	GF	PERFORM CoGS ENVIRO TARGETS	ADD GLOBAL DIT BRAND	END Q3 FY09	MANAGEMENT COMMITMENT TO GET STARTED WITH "NEW" PRODUCT
9.					
10.					

REQUIRED BY PARTNERS

Commitment and follow-up



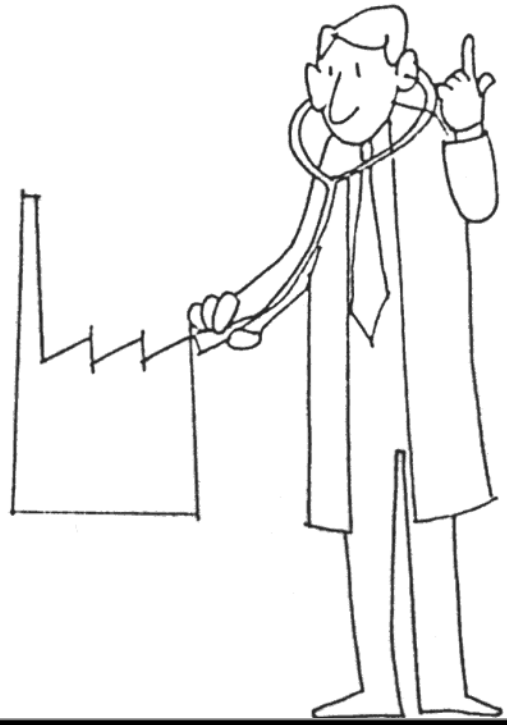
Focus area 3:

Mandate sustainability in the value chain

First take a look inside the company

- *"The solely economical assessment of products must change into a **well balanced valuation of economical and ecological issues**. To fulfil these requirements an optimised cooperation of technological development, legislation measures, and the social way of acting is essential."*

[Feldmann, 1994]
Recy'94 seminar (CIRP), Erlangen



An organisation's environmental readiness

Content and activities

Clear goals for product development

Methodologies

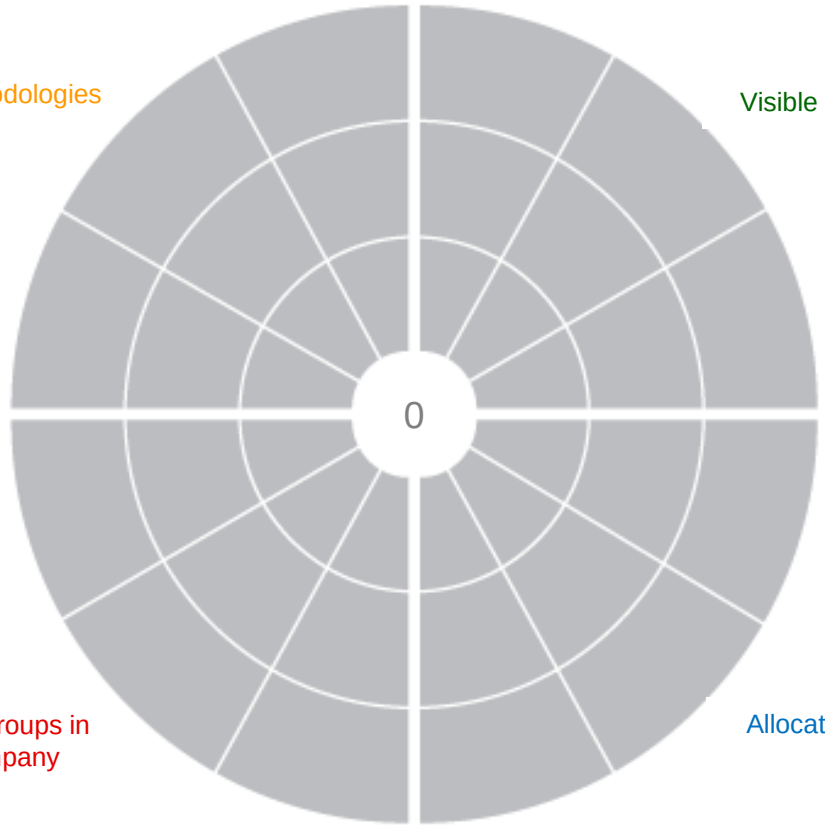
Tools

Environmental communication

Environmental champion

Visible environmental goals in the company

Visible environmental reporting



Project team

Working groups in the company

External partners or network

Environmental agenda in management

Allocation of time for environmental thinking in NPD

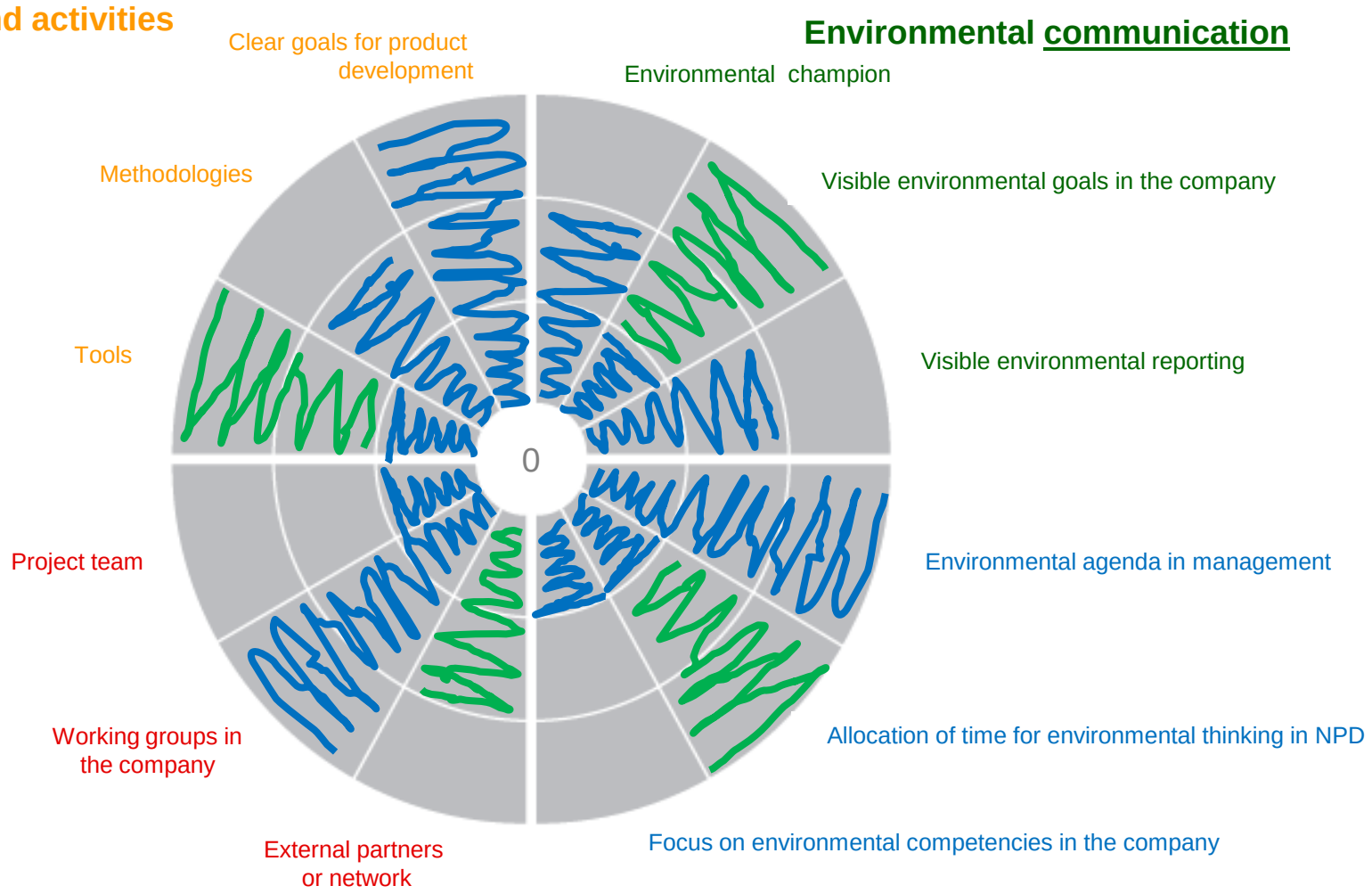
Focus on environmental competencies in the company

Collaboration and network

Organisation of the environmental task

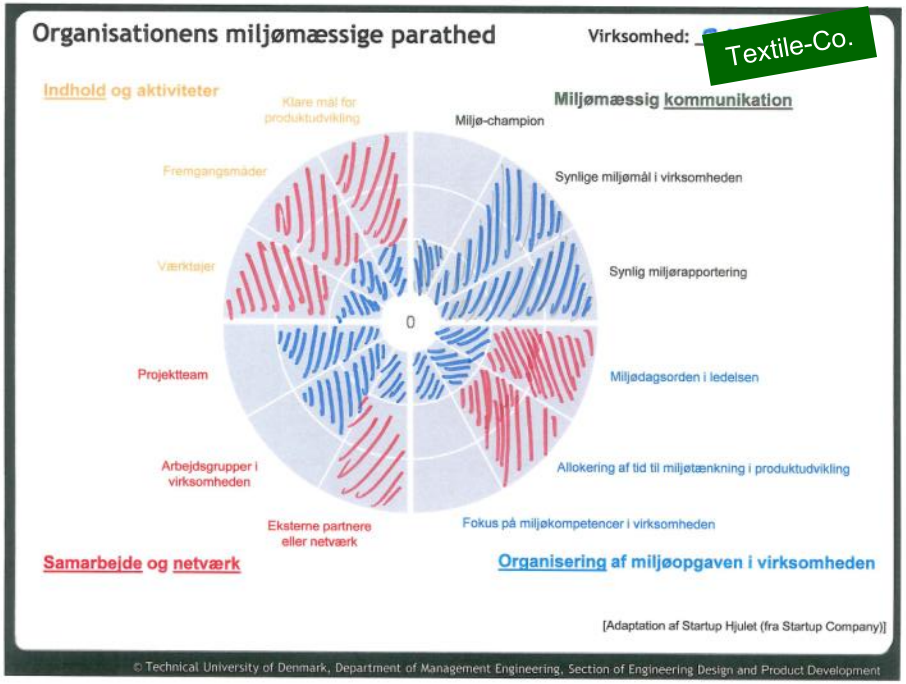
[Adaptation of Startup wheel (from Startup Company)]

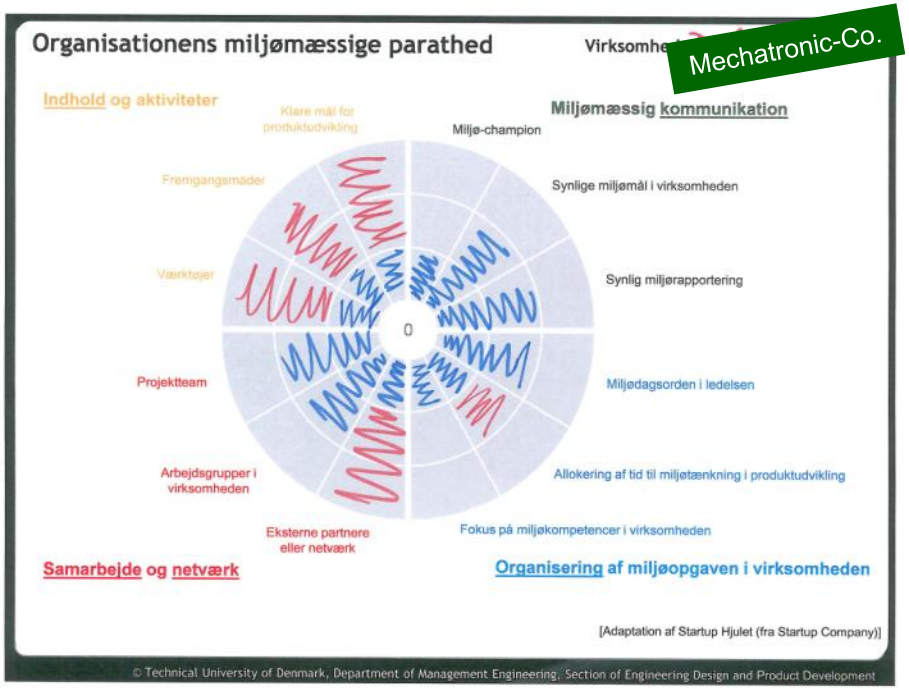
An organisation's environmental readiness



[Adaptation of Startup wheel (from Startup Company)]

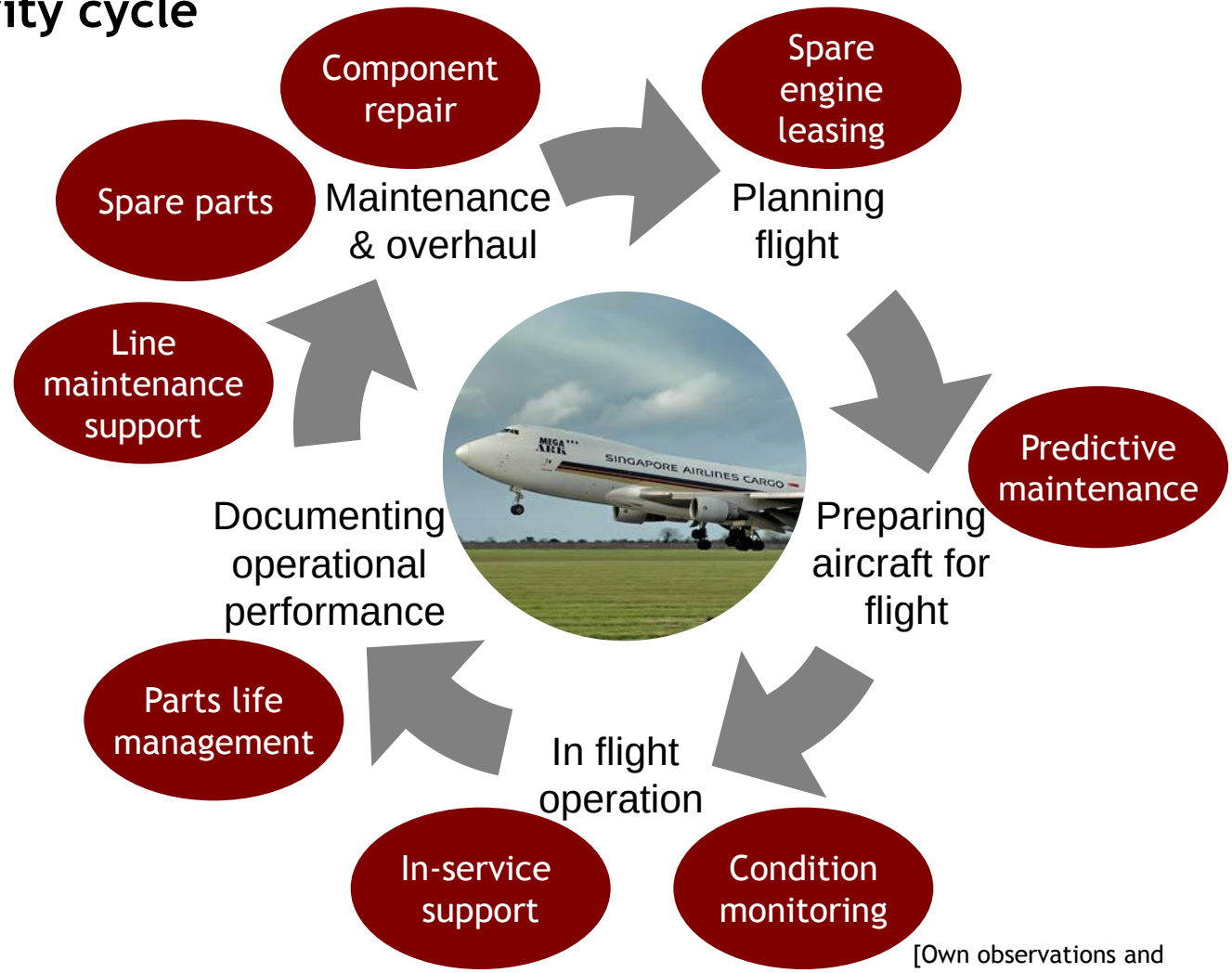
An organisation's environmental readiness





Innovating in the value chain:
PSS example from Rolls Royce

Customer activity cycle

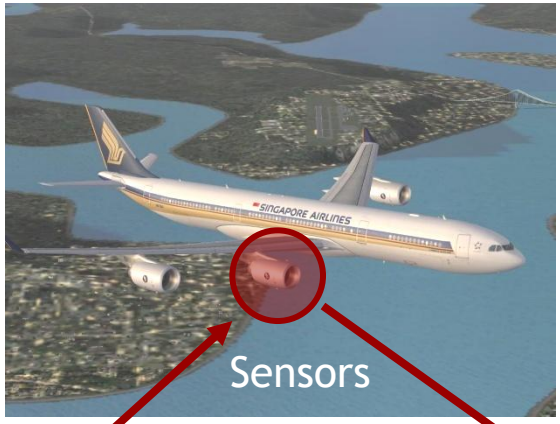


[Own observations and interpretations, from literature]

Innovating in the value chain:
PSS example from Rolls Royce

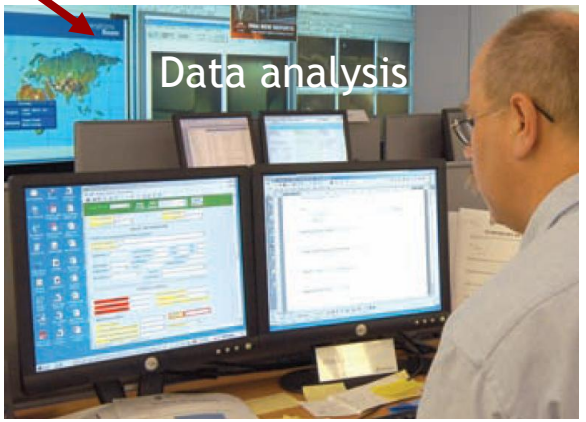
Engine Health Monitoring

Engine in operation



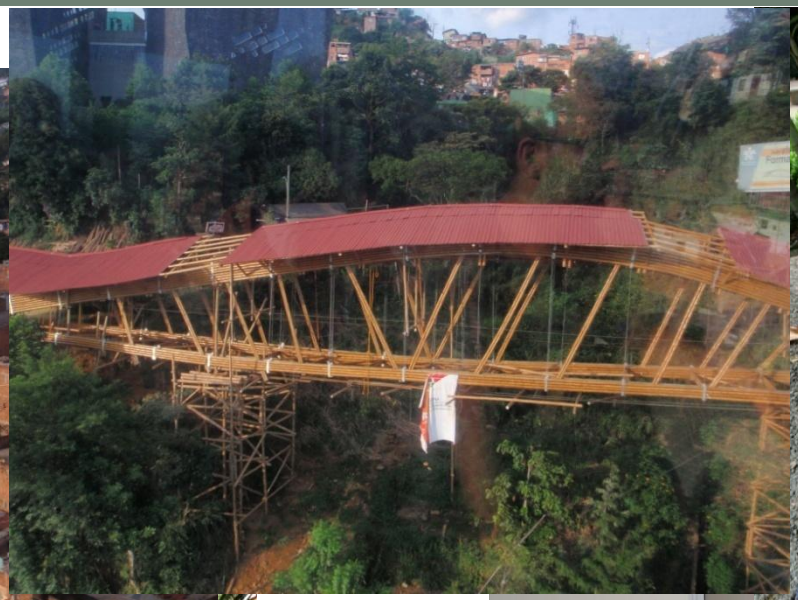
Maintenance & repairs

Operations Room



[Own observations and interpretations, from literature]

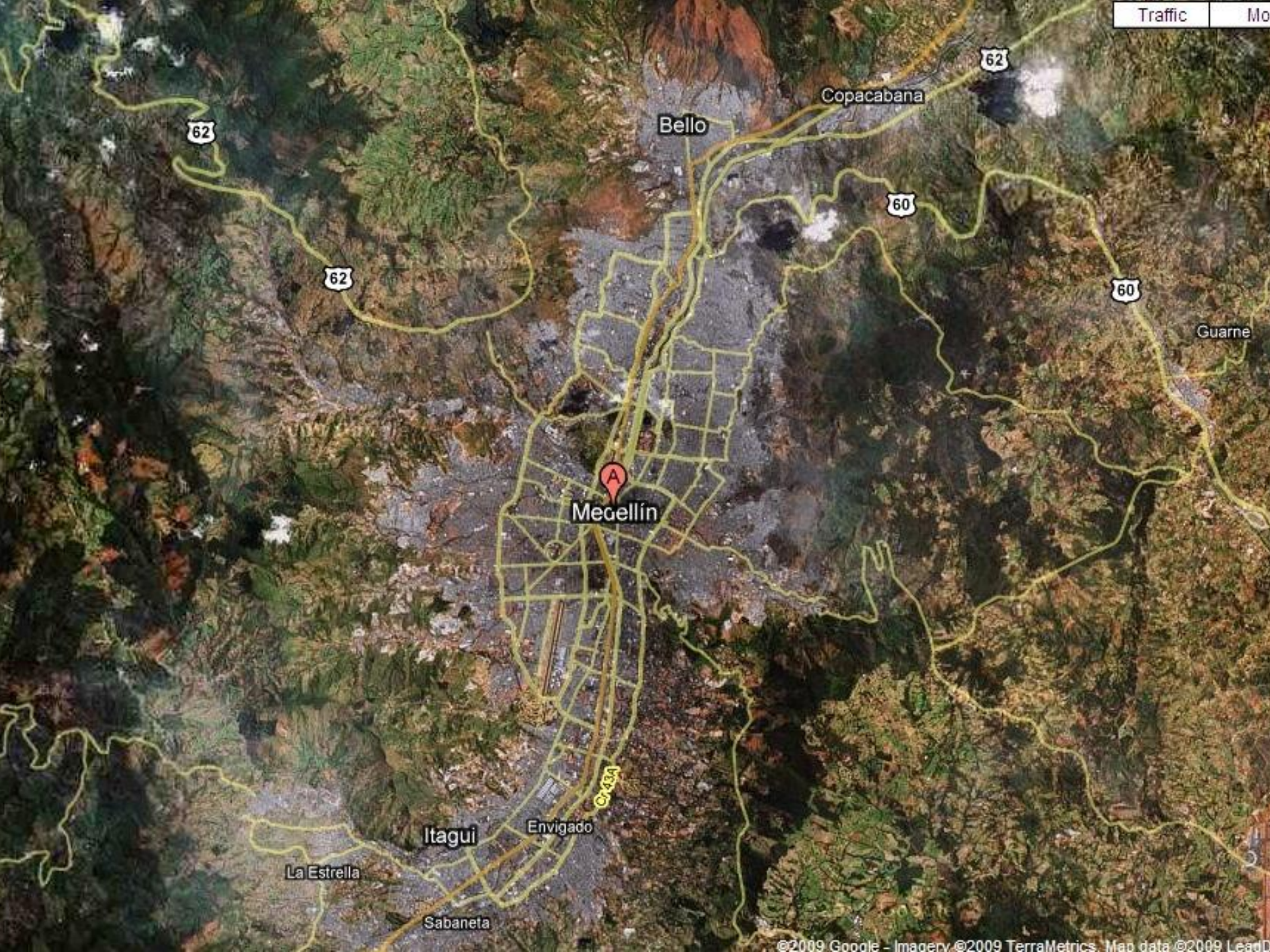
Sustainable design in a broader perspective
Research work in Colombia, 2009



Developing Industries in Colombia, 2009

- Oil and gas
- Mining
- Agro-industry
- Renewable energy
- Oleo-chemistry (e.g. from palm oil)
- Mobility
- Health
- Tourism
- …..

- Small, Family owned and administered business
- Conservative
- Local Thinking
- Low capital
- Risk aversion


Traffic
Mo
62
62
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Copacabana
Bello
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60
Guarne
Medellín
Itagui
Envigado
La Estrella
Sabaneta
©2009 Google - Imagery ©2009 TerraMetrics, Map data ©2009 Lead

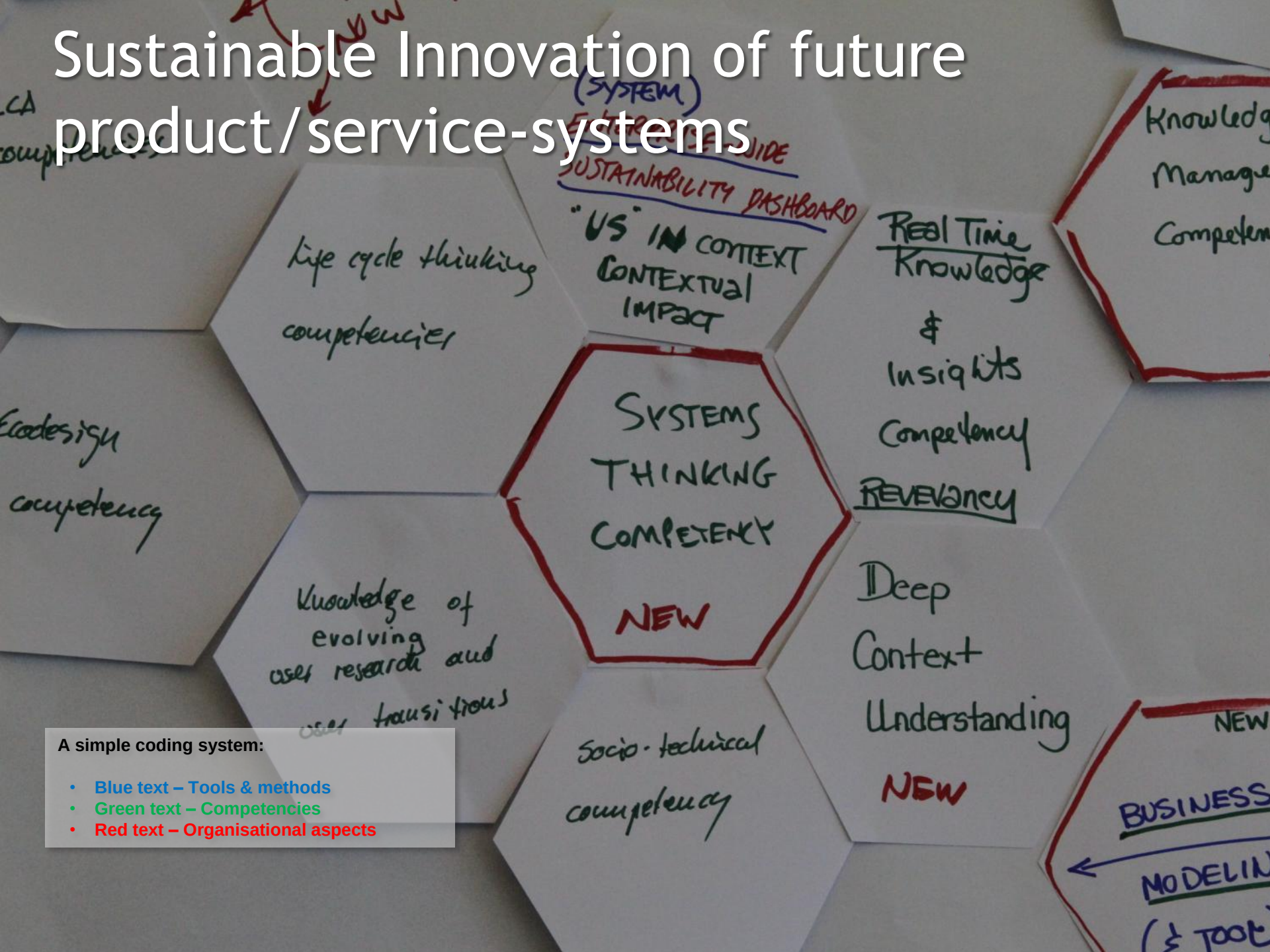
Focus area 4:

Sustainability as a driver for innovation

Sustainability as a driver for innovation

Workshop 2: Panasonic, Steelcase, Coloplast, LEGO & Velux in Copenhagen - September 2010

Sustainable Innovation of future product/service-systems



A simple coding system:

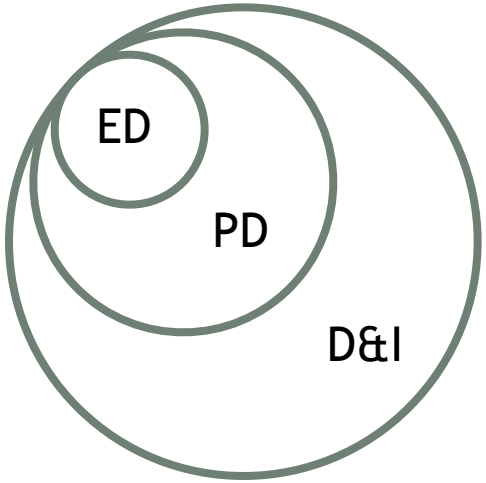
- **Blue text – Tools & methods**
- **Green text – Competencies**
- **Red text – Organisational aspects**

Creating a Sustainable Innovation Roadmap

Teaching ecodesign / sustainable design:
Cases from the classroom

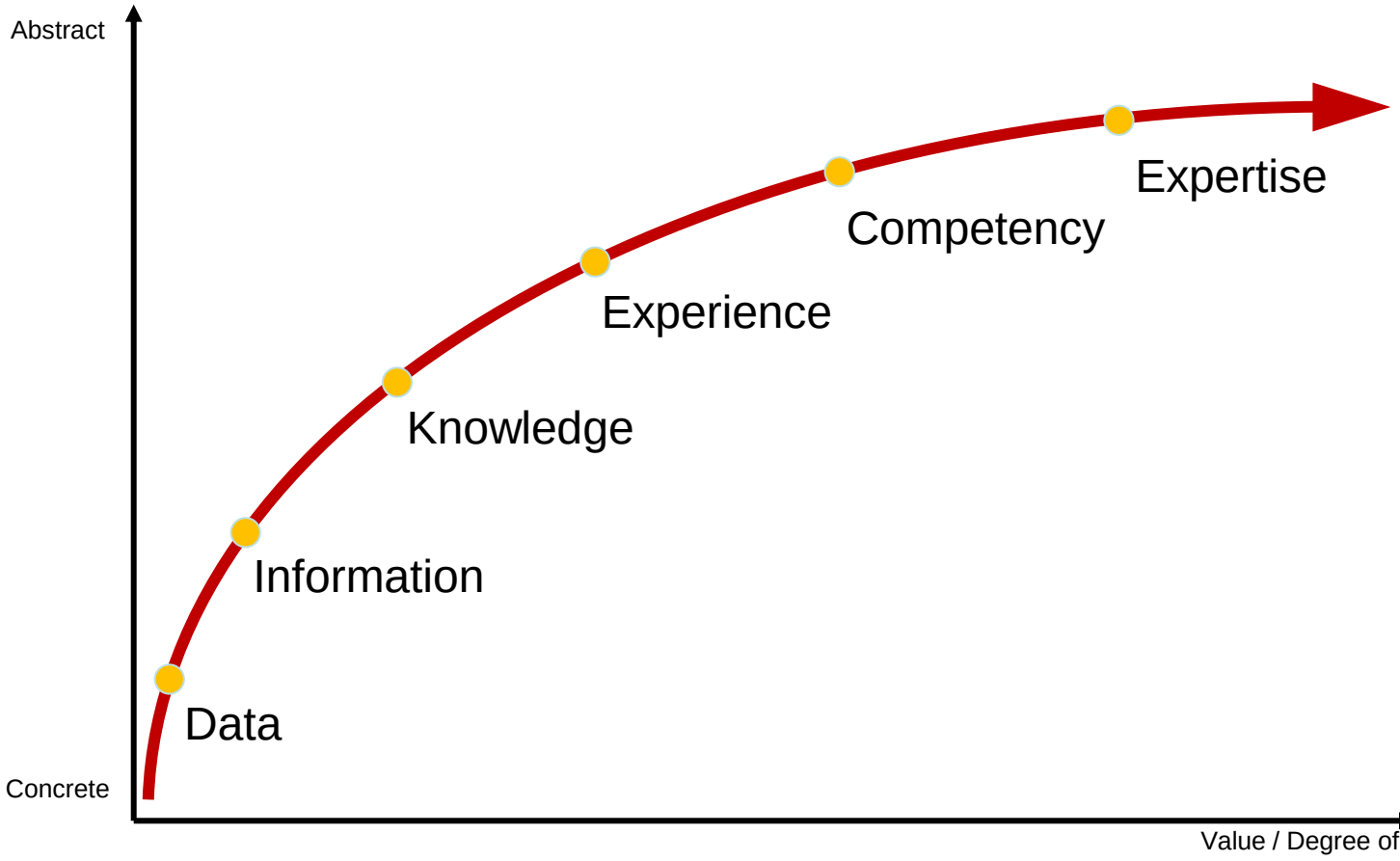
Development of research and teaching focus in our group

- 60ies : Engineering Design
- 80ies : Engineering Design + Product Development
- 00's : Engineering Design + Product Development + Design & Innovation



Competency as an aim for university learning

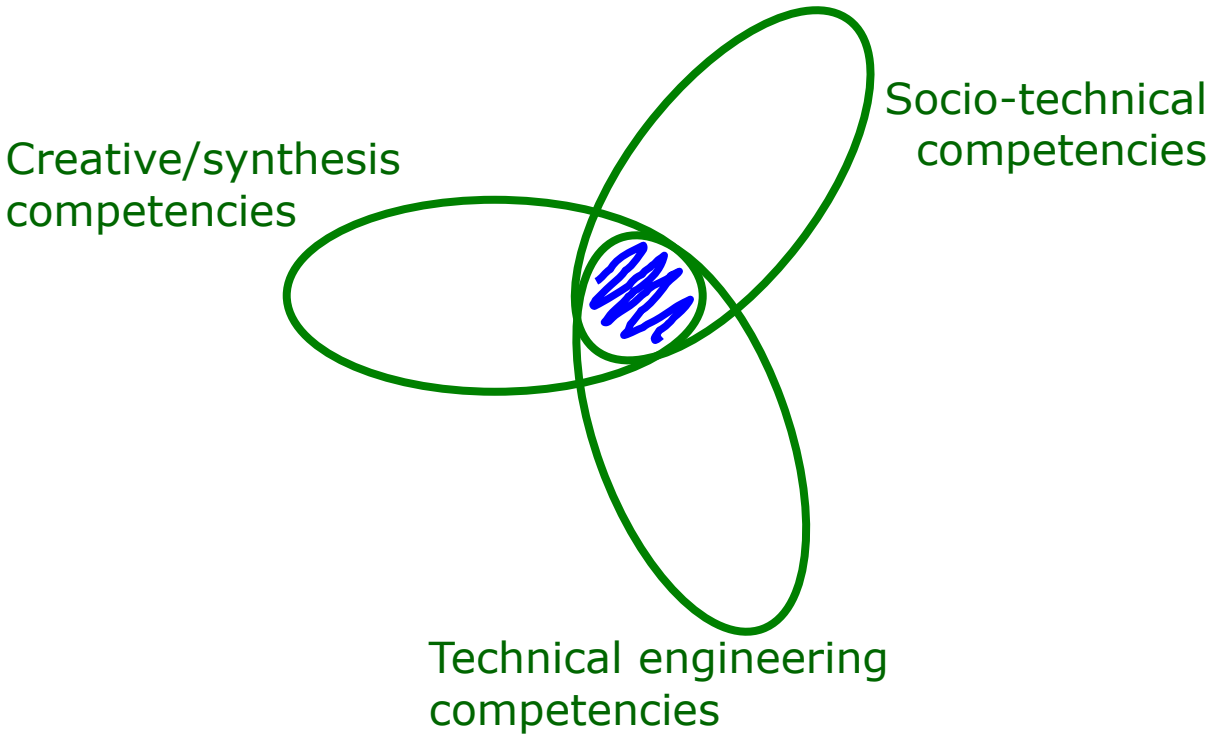
- Creating professional engineers with not just knowledge and skills, but also attitude, experience and competency



[Mental model by McAloone]

Educational concepts for innovation (1/2)

- Strong focus on competencies in three main areas:



Educational concepts for innovation (2/2)

- T-Shaped professionals

Many multi-cultural-team service projects completed
(resume: outcomes, accomplishments & awards)

Many disciplines
(understanding & communications)

Many systems
(understanding & communications)

Deep in one discipline
(analytic thinking & problem solving)

Deep in one system
(analytic thinking & problem solving)

[Jim Spohrer, IBM, 2011
(after Tim Brown, IDEO)]

The Design & Innovation education programme
(Bachelor level)

Semester themes

Points:	5	10	15	20	25	30
1	41010 User-oriented design		41012 Visual communi-cation	42011 Product usa-bility and design	41015 Mechanics and materials	
2	42020 Product analysis and redesign			42021 Technology analysis	41025 Ob-ject-orien-ted design and progr.	01007 Linear and differen-tiable mathe-matical mo-dels
3	41030 Mechatronics engineering design		41031 Industrial design	Optional subject 41818 CAD/CAM	41035 Dynamics and vibra-tions	
4	42040 Workspace design		42041 Design of work pro-cesses	Optional subject	41026 Electronic design	41045 Thermo-dynamic modelling
5	Optional subject 42050 Product service systems		Opt. subj. 41051 Prod. life and envi-ronm. iss.	Optional subject	02569 Light, materials, visuality	01037 Signals and linear systems
6	Bachelor project			42061 Scenarios and concepts	Optional subject	41065 Fields and flows

semes

Meet the world of technology

The good product

Design engineering

Product synthesis

Innovation for sustainability

Concept innovation

The Design & Innovation education programme
(Masters level)

Specialisation in innovation management

Point:	5	10	15	20	25	30
						Optional subject

Specialisation in systems design

Point:	5	10	15	20	25	30
						Optional subject
						Optional subject
						Optional subject

Specialisation in product design

semester	5	10	15	20	25	30
7	41080 Design methods		41071 Development projects in companies	41072 Design for interaction	Optional subject	Optional subject
8	42070 Holistic design		42085 Strategy, design and market	41083 Technology platforms and architectures	Optional subject	Optional subject
9			42075 Knowledge and innovation in networks	42091 Products and consumpt. in everyday life	Optional subject	Optional subject
10	Exam project					

First semester project – user-oriented design

Analysis meets synthesis

Second semester project – analysis and redesign

Third semester courses

Industrial design meets mechatronics – or Form vs. function

Pride in product development!

Fifth semester – Sustainable product and product/service-system design

Projects:

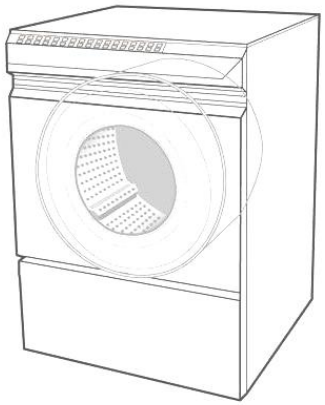
- Sustainable kitchen of the future
- Radical re-design of energy using products
- Sustainable home heating systems
- The sustainable DTU campus
- The intelligent and eco-friendly home

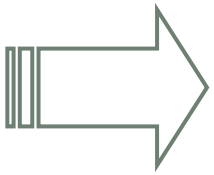
Course exercise types:

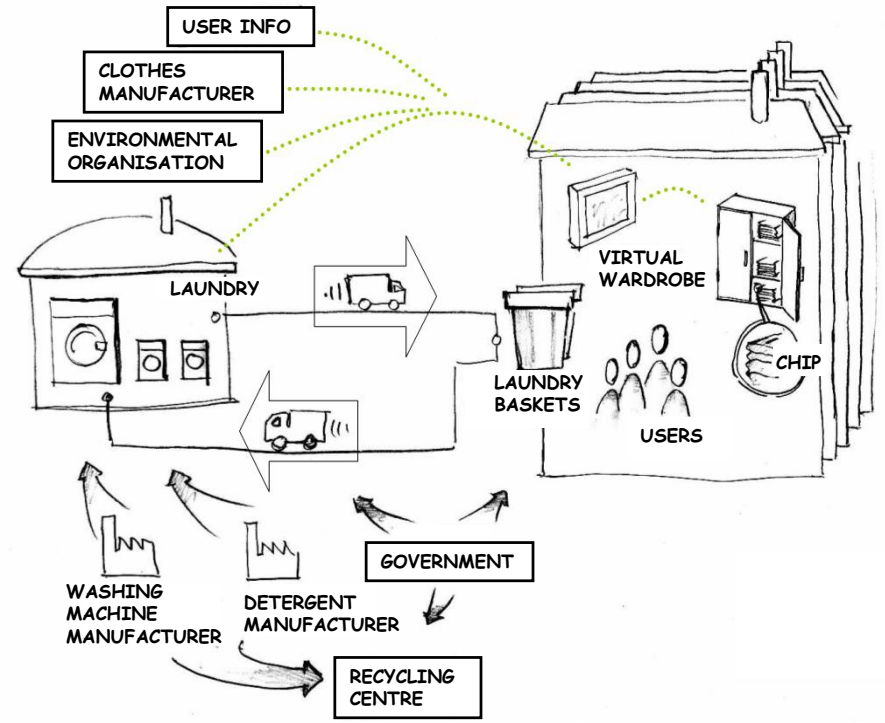
- Ecodesign games
- Eco-article
- Review af eco-article

Fifth semester project – Sustainable product/service-system design

From washing machine to clean clothes



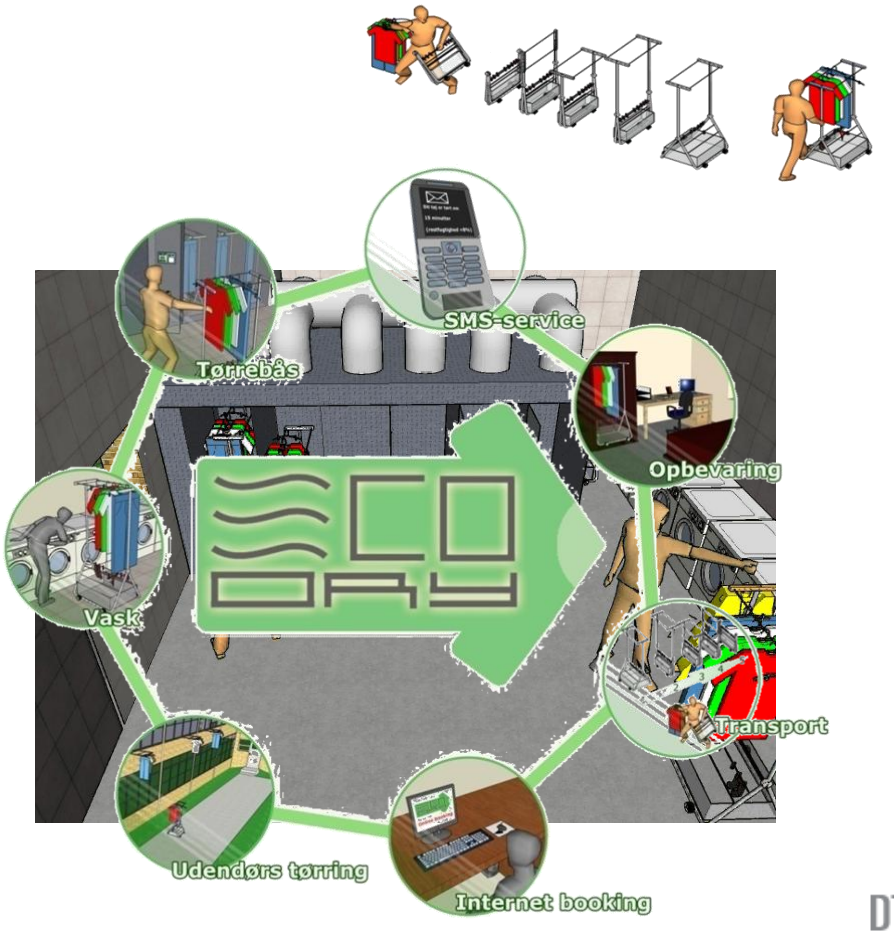




[design.ing student project, 2005]

Fifth semester project – Sustainable product/service-system design

From tumble dryer to integrated drying and hanging system



[design.ing student project, 2006]

Task: Eco-game

The game can be general, or geared towards a particular industry

Task: Eco-game

The game encourages the students to think in terms of product, application, service and activity – product lifecycle

Task: Eco-game

New type of examination situation …


Building design course
25/2-2010

Reflections

- **Tools for product analysis and redesign** are good and useful, but not ***the*** answer alone
- Companies still need **easily accessible methods for ecodesign**, and need help in implementing them
- **Design the life cycle first** – it affects the product too
- The company must take on **responsibility in the value chain** – there's also lots of business to be won here
- Sustainability can be seen as a **driver for innovation**
- All of this is, of course, **teachable** - but it's equally as important to make sure that it's **learnable**!

Questions?

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